BIOLOGICAL INVENTORY PLAN

THE SIERRA NEVADA NETWORK
NATIONAL PARK SERVICE

Prepared by

The Sierra Nevada Network Working Group

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SECTION 1 - INTRODUCTION

1.1 Goals and Objectives of the Sierra Nevada Network

This *Biological Inventory Plan* targets the completion of basic inventories of vascular plants and vertebrate animals for the parks of the Sierra Nevada Network. Sierra Nevada Network parks include Devils Postpile National Monument and Sequoia, Kings Canyon and Yosemite National Parks. The plan's purpose is to provide park managers in the network, NPS policy-makers, and publics with scientifically sound information on the nature and status of selected biological resources in a readily accessible form. Because of the great biophysical and geographic affinities of all the units in the network, the network concept offers efficiencies in designing and conducting inventory work, and improved opportunities for exchange of ideas and information among parks.

The objectives of this inventory plan are as follows:

- To document through existing, verifiable data and targeted field investigations the occurrence of at least 90 percent of the species of vertebrates and vascular plants currently estimated to occur in the parks.
- To describe the distribution and relative abundance of species of special management concern, such as listed Threatened and Endangered species, invasive alien species, and other species of special management interest occurring within park boundaries.
- To provide the baseline information needed to develop a general network "vital signs" monitoring strategy, based on an understanding of ecosystem function and designed to address system stresses and park resource issues.
- To develop a coordinated network data management program that results in biological resource information being easily accessible to park managers, policy-makers, scientists, and the public.

1.2 Biophysical Overview

Devils Postpile National Monument

Devils Postpile (DEPO) is a 324 ha unit located high on the western slope of the Sierra Nevada in Madera County, California. Elevations within the Monument range from 2,200 m to 2,500 m. While huge areas of the Sierra Nevada granite batholith are exposed, about 100,000 years ago, basalt lava flowed into the area. The specialized fracturing that occurred during the cooling of the lava resulted in the formation of tall columns. Nearly 10,000 years ago, a glacier overrode the fractured lava mass exposing a wall of columns 18 meters high resembling a giant pipe organ. Also located in Devils Postpile is the spectacular Rainbow Falls where the San Joaquin River drops 31 m over a volcanic cliff.

Although the San Joaquin River drains the length of the Monument into the San Joaquin Valley to the west, the Ritter Range west of the Monument is higher in elevation. As a consequence, biological communities in the Monument have east-slope as well as west-slope affinities. The principal vegetation of the Monument is montane forest, mostly dominated by red fir or lodgepole pine. Along the San Joaquin River, typical montane riparian vegetation dominates, represented by quaking aspen, black cottonwood, alder, and willows. Both dry and wet montane meadows occur in the Monument.

Devils Postpile National Monument is surrounded on three sides by the Inyo National Forest, and so comprises a small natural area within a much larger contiguous complex of federal public lands extending over a vast area of the eastern and western slopes of the Sierra Nevada range. The fauna and flora of the Monument are shared with this large natural area. Three-quarters of the Monument is

included within the Ansel Adams Wilderness. To the east of the Monument, and closely allied with it economically, is the town of Mammoth Lakes and the Mammoth Mountain ski complex.

Figure 1 – Map, Sierra Nevada Network Parks and Surrounding Area

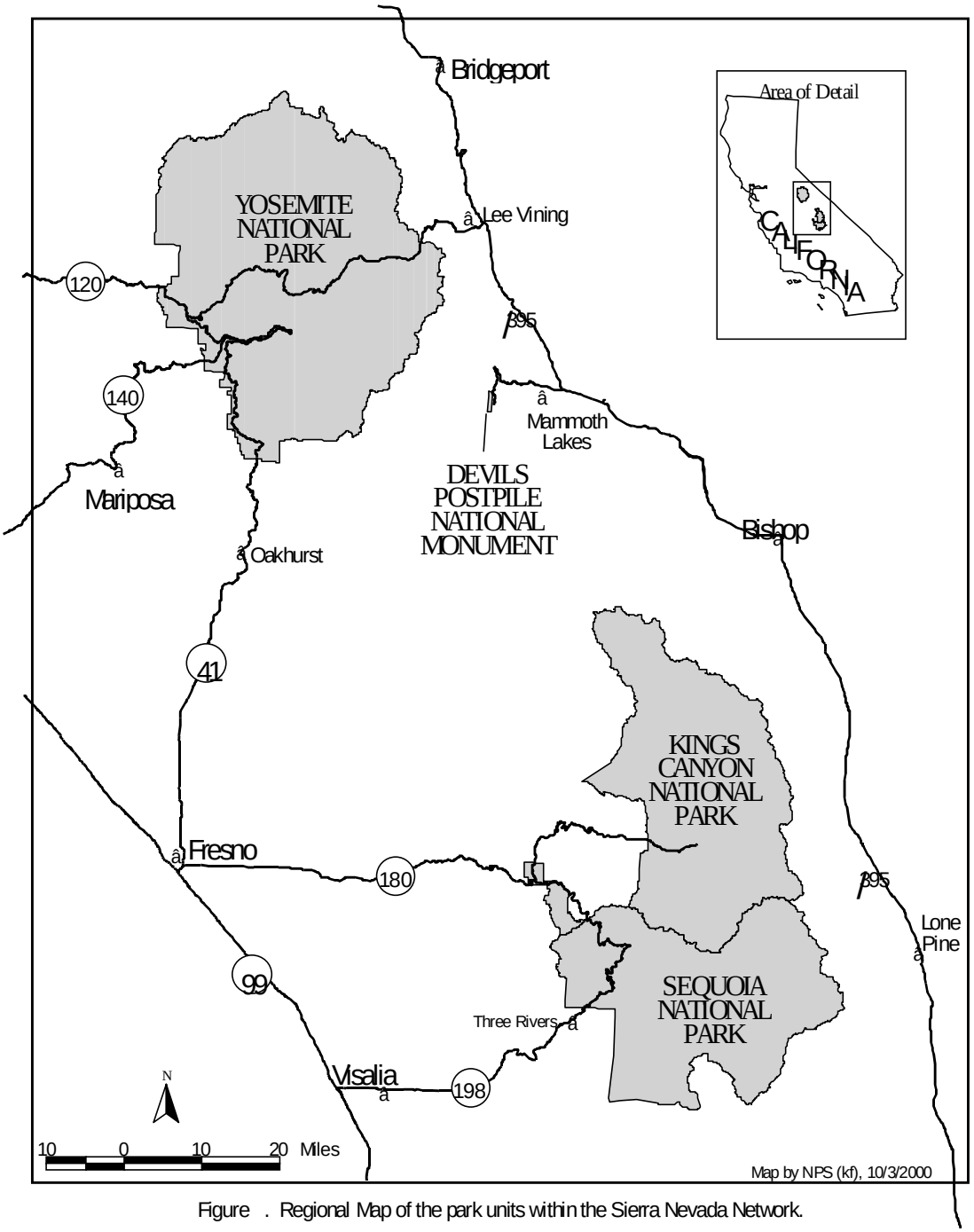


Figure . Regional Map of the park units within the Sierra Nevada Network.

Figure 2 – Map, Devils Postpile National Monument

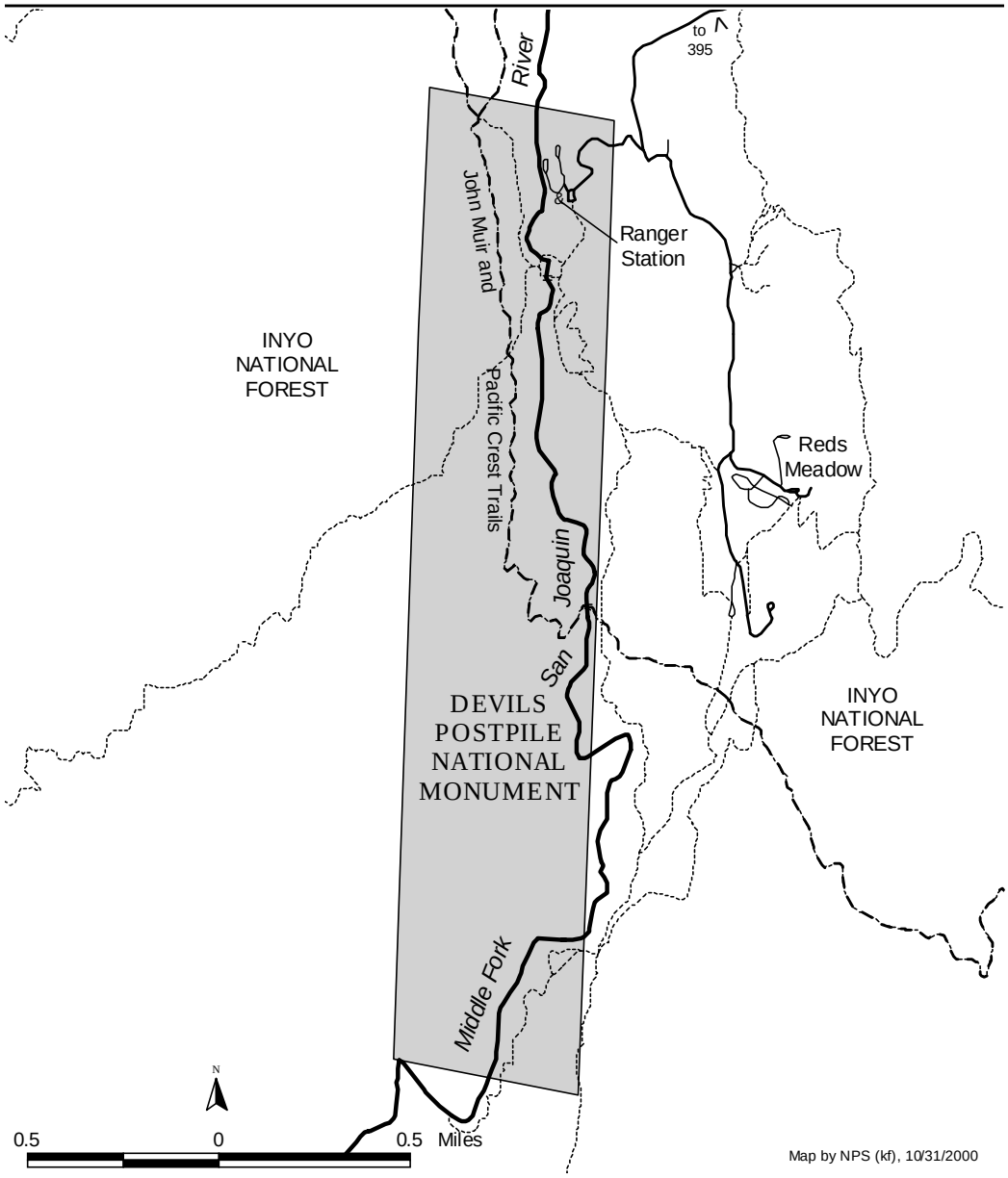


Figure . Map of Devils Postpile National Monument.

Sequoia and Kings Canyon National Parks

Sequoia and Kings Canyon National Parks (SEKI) comprise 349,581 ha located on the western slope of the south-central Sierra Nevada of California in Fresno and Tulare Counties. This is an area of exceptional topographic relief characterized by abundant and diverse changes in vegetation. SEKI ranges in elevation from the low western foothills at 400 m to 4418 m on the crest of the Sierra, and is composed largely of rugged, mountainous terrain. Vegetation is extremely varied, including chaparral, oak woodland and savanna, upland hardwood forest, conifer forests and woodlands, meadows, and alpine plant communities. Three major river systems, the Kings, Kern, and Kaweah, drain the parks. Climate is Mediterranean, with hot, dry summers and cool winters during which most precipitation falls. Above 2,000 m the bulk of this is as snow. The Parks contain more than 200 caves formed in mesozoic limestone. To date, nearly 20 endemic species of invertebrates have been discovered in Park caves, and caves provide roosts for at least six species of bats.

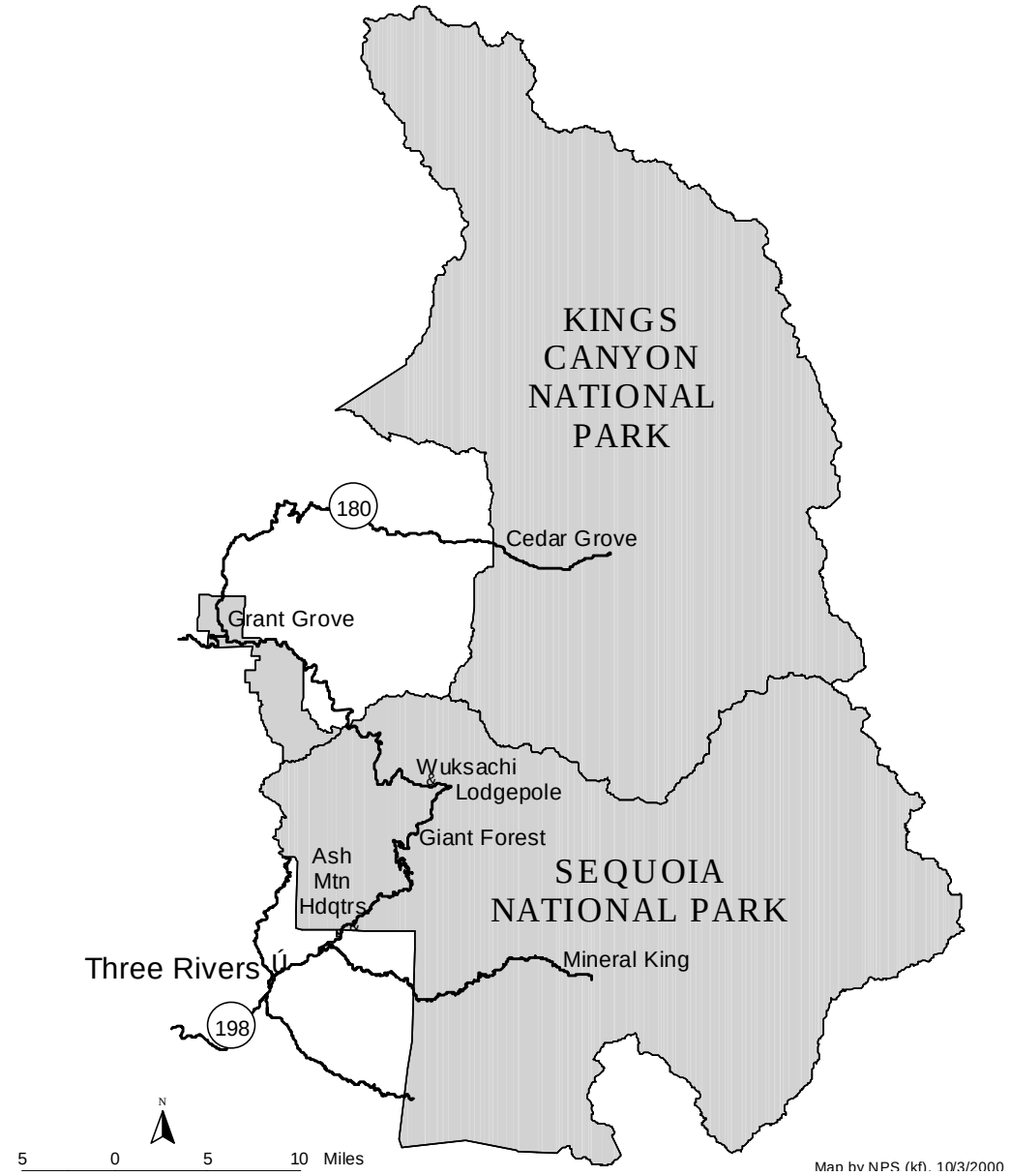
SEKI is 85% legally designated wilderness. The Parks comprise an International Biosphere Reserve (UNESCO Man and the Biosphere Program). There are 1270 km of trails, and 300 km of paved roads. Annual visitation recently has exceeded 1 million people.

The parks are bounded on the north, east, and south by federal National Forest lands mostly designated as wilderness but also used for timber harvest, grazing, reservoirs, and recreation. Lands to the west are largely private, devoted to ranching and farming, and containing villages. The eastern boundary is the crest of the Sierra Nevada; the remaining boundary is a combination of watershed, river, and artificial demarcations. The eastern slope of the range is a steep escarpment.

The region has been occupied by humans for several thousand years. The most recent settlement by aboriginal people occurred ca. 500 years ago. Villages were located in the foothills, with mid-elevation sites used seasonally and high elevations used primarily as trade routes. An earlier occupation, ending at least one thousand years prior, has been established but almost nothing is known of it. When Euro-Americans--first explorers and prospectors, soon followed by sheep and cattle herders--arrived in the area ca. 1850, the local Yokut Indians were using fire on a regular basis, apparently to clear brush and improve forage for game animals such as deer (*Odocoileus hemionus*), and possibly to favor certain wild food crops (Lewis 1973). Although by the mid-1860s Indians had been extirpated or abandoned the area, Euro-Americans continued the practice of burning to improve grazing forage in some areas until establishment of the reserve.

Prior to Euro-American settlement, fire was a frequent and important disturbance factor in the Sierra Nevada ecosystem (Kilgore and Taylor 1979, Swetnam 1993, Caprio and Swetnam 1995, SNEP 1996). Between 1850 and 1870, a dramatic decline in fire frequency occurred in nearly all lower to mid-elevation forests in what is now Sequoia and Kings Canyon National Parks (Caprio and Swetnam 1995). Shifts in the fire regime have been attributed to multiple causes, including intense grazing that removed fine fuels important for fire spread, loss of Native American populations as an ignition source, and more recently, 20th century fire suppression efforts (Kilgore and Taylor 1979, Caprio and Swetnam 1995, SNEP 1996). Virtually all areas of the (present) Parks were subjected to grazing by the 1860s, much of it extreme in intensity. It was during this period that alien Mediterranean annual grass species became established in the lower elevations. Grazing largely ceased at the middle and lower elevations with Park establishment in 1890, but continued in the subalpine and alpine zones for at least another decade. Fire suppression became policy by 1900, and was successfully effected by 1930. Beginning in the late 1960s, fire suppression was gradually replaced by a policy of prescribed burning and allowing naturally ignited wildland fires to burn in some areas, with monitoring by NPS staff (Bancroft et al. 1985).

Figure 3 – Map, Sequoia and Kings Canyon National Parks



Yosemite National Park

Yosemite (YOSE) is 302,687 ha of scenic wildlands set aside in 1890 to preserve a portion of the central west slope of the Sierra Nevada that stretches along California's eastern flank in Tuolumne, Mariposa, and Madera Counties . The park ranges from 607 m to nearly 4000 m elevation and includes among its attractions alpine wilderness, three groves of Giant Sequoias, and the glacially carved Yosemite Valley with impressive waterfalls, cliffs and unusual rock formations. Approximately 94% of Yosemite's acreage is legally designated Wilderness. Yosemite is designated a World Heritage Site as part of an international system of sites set aside to preserve internationally significant natural and cultural resources. The El Portal Administrative Site west of the park, at approximately 566 hectares, was purchased in 1958 for the purpose of relocating park facilities. U.S. Forest Service lands surround the park and are divided into four national forests: Stanislaus, Toiyabe, Inyo, and Sierra. The California Wilderness Act of 1984 established portions of the Tuolumne River (including the Dana and Lyell Forks) as part of the Wild and Scenic Rivers System. In 1987, Congress also designated the main stem and the South Fork of the Merced River as part of the Wild and Scenic Rivers System.

Yosemite National Park is about 240 kilometers east and four hours by car from San Francisco, and about 440 kilometers north and six hours from Los Angeles. There are five entrances to the park. Four are on the west side of the Sierra Nevada: the Big Oak Flat Road, the El Portal Road, Hetch Hetchy Road, and Wawona Road. The Tioga Road offers seasonal access from the east side of the Sierra Nevada. Current annual visitation to the park is nearly 4 million.

The geology of Yosemite is characterized by granitic rocks and remnants of older rock (Huber 1989). In the early Tertiary period, 40 to 60 million years ago, the geologic environment of the Sierra Nevada region was lower in elevation, with a gently rolling upland surface. The Merced River flowed at a gentle gradient westward through a broad river valley. About 10 million years ago, the Sierra Nevada was uplifted and then tilted to form its relatively gentle western slopes and the more dramatic, steep eastern slopes. The uplift increased the flow gradients, resulting in deep, narrow canyons.

About 1 million years ago, snow and ice accumulated, forming glaciers at the higher alpine elevations that began to move westward down the river valleys. Ice thickness within Yosemite Valley may have reached 4,000 feet during the early glacial episode. The downslope movement of the ice masses cut and sculpted the U-shaped valley evident today. After the last glacier left the valley about 15,000 years ago, a lake referred to as Lake Yosemite was formed behind the materials deposited by the glaciers. More than 1,000 feet of glacial and stream sediment now underlies the floor of Yosemite Valley and cover glacially disturbed granitic rock (Huber 1989).

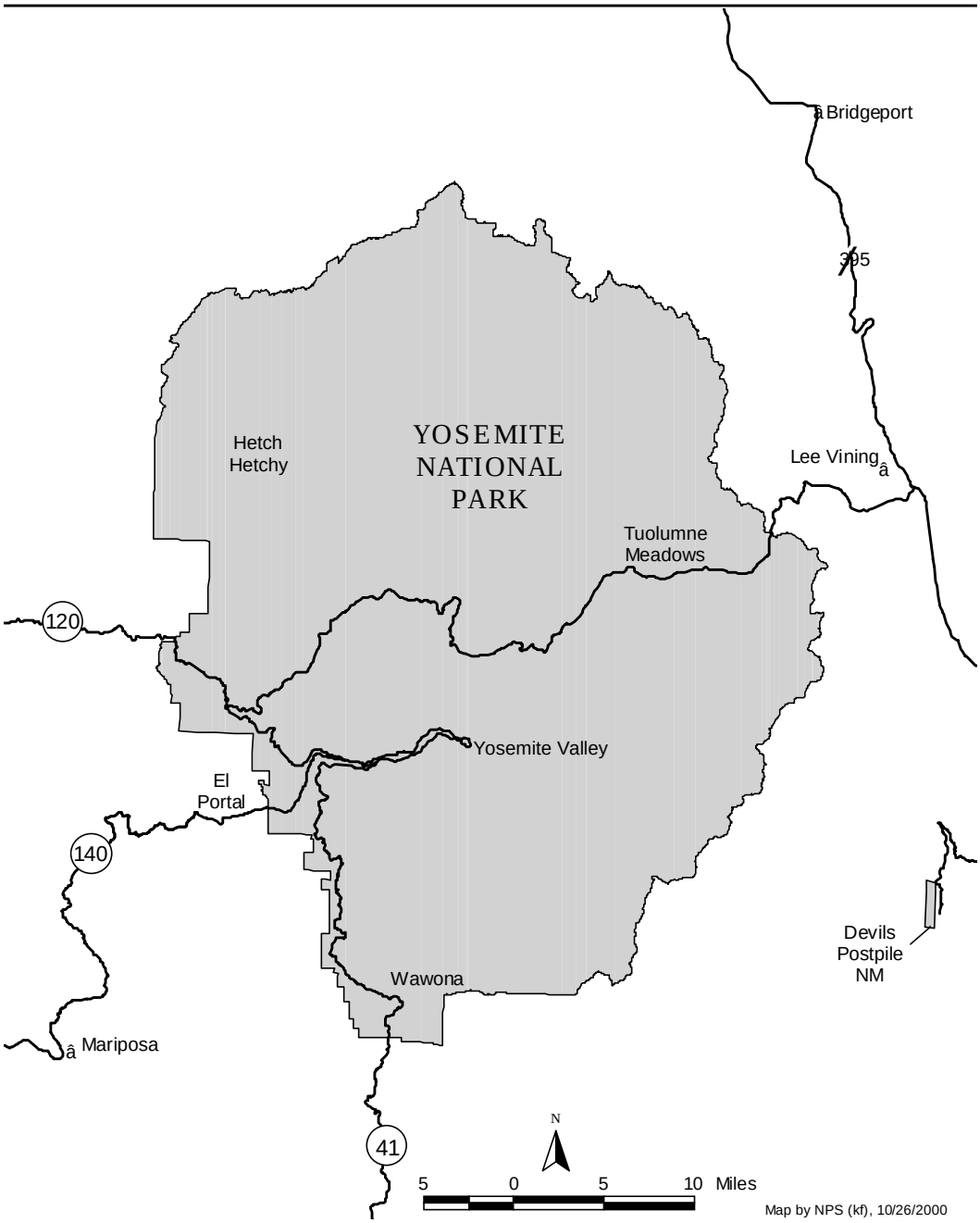
Yosemite National Park, one of the largest and least-fragmented habitat blocks in the Sierra Nevada, supports a diverse and abundant assemblage of plants and wildlife. Its importance in protecting the long-term survival of certain species and the overall biodiversity of vegetation and wildlife in the Sierra Nevada was recognized in reports prepared as part of the Sierra Nevada Ecosystem Project (SNEP 1996).

The major vegetation zones in Yosemite form readily apparent, large-scale, north-south elevational bands along the axis of the Sierra Nevada. Major east-west watersheds that dissect the park into steep canyons form a secondary pattern of vegetation. Yosemite National Park supports five major vegetation zones: chaparral/oak woodland, lower montane, upper montane, subalpine, and alpine. The park is rich in plant diversity. Of California's 7,000 plant species, about 50% occur in the Sierra Nevada and more than 20% within Yosemite. There are documented records or suitable habitat for 164 special status plant species in the park. As a group, Sierra Nevada plants are most at risk where habitat has been reduced or altered. However, rare local geologic formations and the unique soils derived from them have led to the evolution of ensembles of plant species restricted to these habitats. This is true in the El Portal area, where a number of state-listed rare species are sustained in a unique contact zone of metamorphic and granitic rock.

Approximately 85 native mammal species in six families inhabit Yosemite. There are 17 species of bats, 9 of which are either Federal Species of Concern or California Species of Special Concern. Ungulates include large numbers of mule deer. Bighorn sheep formerly populated the Sierra crest, but have been reduced to several remnant populations, none of which regularly occur in Yosemite. Grizzly bears once occurred in the park, but were extirpated from the state by the early 20th century. Black bears are abundant in the park, and are often involved in conflicts with humans that result in property damage, injuries to humans, and the need to kill black bears that present a clear threat. For unknown reasons, Pacific fishers are present in very low numbers in the park. Road-kills and low numbers of porcupines (an important prey species) may be factors.

Humans have lived and sustained themselves in the region for at least 9,000 years and are part of the Sierra Nevada ecosystem. Indigenous populations were widely distributed throughout the area at the time of Euro-American immigrations. Archeological evidence indicates that for more than 3,000 years American Indians practiced localized burning, harvesting, pruning, irrigation, and vegetation thinning. Immigration of Euro-American settlers in the mid-1800s began a period of increasingly intense resource use and settlement (SNEP 1996). As in Sequoia and Kings Canyon National Parks, Yosemite fire history studies document a decline in frequent, widespread fires by the mid 1800s (Swetnam 1993, Swetnam et al. 1998). This disruption of the surface fire regime corresponds to the introduction of large numbers of sheep and other livestock into higher elevation forests of the Sierra Nevada during and following the drought of the early 1860s (Swetnam et al. 1998). Yosemite National Park has used prescribed fire since 1970 and monitored lightning-ignited fires since 1972 to reduce fuels and return fire to the landscape (van Wagtendonk 1977).

Figure 4 – Map, Yosemite National Park



1.3 Management and Scientific Issues

Vascular Plants

Most plant communities in the parks of the Sierra Nevada Network today are fairly intact as compared to similar non-Wilderness areas outside the park boundaries. Much of this "pristine" quality can be attributed to relatively low levels of historic and/or recent human-caused disturbance, and the lack of disruption of natural processes. The notable exception to this is the replacement by introduced Eurasian species of the herbaceous understory in the foothill savannas and woodlands of Sequoia National Park and the meadows of Yosemite Valley. However, impacts to plant communities, species, and individuals can be found throughout all the parks. Past logging and grazing continue to affect hydrology and soils, and thus vegetation, in many areas of the parks, including parts of the subalpine and alpine environments.

More recent manipulations of the environment have resulted in alterations in the vegetation in many locales. These forcing agents include suppression of natural fire frequencies, local water diversions or water impoundments, and development of infrastructure throughout the non-Wilderness portions of the parks. In addition, changes in these natural processes of fire and flooding have resulted in changes in the effects of re-introduced fire or in more recent floods, including sometimes greater fire intensities and severities in all parks, and depth of flooding, scour and depositional patterns in Yosemite. Finally, the level of recreational use today in the most popular areas of the parks, although quite localized, has led to trampling, loss of vegetative cover, and increased susceptibility to the introduction of non-native plant species. The latter are brought in on vehicles, in construction and maintenance materials, as well as on the feet and hooves of visitors and their animals. All of these factors have lead to the identification of management issues requiring far better inventory data than presently exist.

Riparian and wetland areas contain important plant and animal habitat, yet they receive recreational use out of proportion to their occurrence. Trampling and streambank damage associated with this use introduce disturbance factors that favor exotic plant establishment in areas especially susceptible to non-native intruders, further degrading this critical ecotonal habitat between the aquatic and upland terrain.

Fire is a profoundly important ecological process in these systems, but both prescribed and wildland fires can create conditions that promote exotic plant establishment. On the other hand, fire suppression activities contribute to the introduction of exotic plant propagules while creating conditions for their establishment. Decades of fire suppression upset the competitive balance among many native plant species, and jeopardized the viability of some fire-dependent species.

Air pollution, especially in the southern Sierra Nevada, has affected the vitality of some plant species studied, and may be extensively altering the competitive balance and overall productivity of some plant communities. Global climate change, if it takes place as predicted, is expected to lead to striking changes in the distribution, persistence, and character of many plant communities throughout the range.

Although moderately-extensive plot networks in Kings Canyon, Sequoia, and Yosemite have provided good information on the distribution and habitat affinities of the commoner species of plants, little is known regarding the distribution of rare and special status plant species beyond limited surveys during the 1980s. Information on current population trends is non-existent, making impossible any comparisons of population trends between the park and on adjacent lands with differing management strategies.

Vertebrate Animals

Habitats and wildlife populations in the Sierra Nevada Network parks are thought to be relatively intact, compared to other areas of the Sierra Nevada where human activities such as hunting, logging, grazing, fire suppression, and extensive development have led to widespread degradation, particularly in the lower elevations outside Wilderness. In the parks, however, some human activities and development have affected wildlife and habitats. The most notable example is the inundation of Hetch Hetchy Valley by the construction of the O'Shaughnessy Dam across the Tuolumne River in Yosemite, destroying riparian, oak woodland, and wetland habitats that comprised a substantial portion of all bottomland winter habitat in that park. Similar habitats survive in Yosemite Valley, but roads and dense development in the east end of the Valley have removed or fragmented them, and high levels of human activity from millions of visitors cause disturbance of wildlife. In Kings Canyon, Sequoia, and Yosemite, local areas of montane to subalpine habitats have been developed in ways detrimental to some native animals, but these represent a relatively minor proportion of available habitat.

In some park habitats, particularly chaparral, hardwood forest and woodland, and mixed-conifer, a long history of fire suppression has affected the natural structure and succession of plant communities, which has affected habitat quality for wildlife. In some cases, this has also led to fires of unnaturally high intensity, which have drastically altered habitats for many years to come. In others, gaps that would otherwise form in conifer forest from natural fires, and provide plant forage species, have been greatly reduced.

Introduction of non-native species has affected some native wildlife species in the parks. The introduction of several species of salmonid fish to high-elevation lakes and streams that were naturally fishless radically altered the fauna communities of those waters and is suspected to be the primary cause of the disappearance of mountain yellow-legged frogs (*Rana muscosa*) from wide areas of its former range throughout the Sierra Nevada. Population declines of Yosemite toads (*Bufo canorus*), and the complete disappearance of foothill yellow-legged frogs (*Rana boylei*) may also be at least partially due to non-native species. Bullfrogs (*Rana catesbeiana*) are present in Yosemite Valley, some foothill portions of Sequoia, and several lakes in the north part of Yosemite, where foothill yellow-legged frogs, or California red-legged frogs (*Rana aurora draytoni*), a Federal Threatened species, once existed. Bullfrogs also prey on western pond turtles found in Sequoia. Brown-headed cowbirds (*Molothrus ater*), recent arrivals in the Sierra Nevada, flourish at stables, campgrounds, and residential areas of the parks, and affect native bird species through nest parasitism. Several species of warm-water fish have been introduced to the lower waters of Sequoia National Park, with unknown effects.

Other adverse effects on the parks' wildlife originate outside the parks. For example, willow flycatchers (*Empidonax traillii*), a Federal Threatened species, have become recently rare in the parks, although their favored habitat, meadows with willow thickets, is largely intact. The Sierra-wide decimation of willow flycatchers, primarily from grazing and clearing of habitat and perhaps cowbird parasitism, has affected the numbers of this species in the parks as well, by reducing the regional population to such a low number that it is difficult for park populations to be self-sustaining. Such regional effects on habitat likely affect a wide range of species in the parks that are migratory or rely on immigration of individuals from adjacent areas.

In general, the parks' ability to respond to threats has been hindered by a lack of comprehensive data on wildlife and habitats. Without such data, we are often forced to make "best guess" evaluations of development and management actions for potential effects on park wildlife.

1.4 Progress to Date

The following items, identified in the Sierra Nevada Network pre-proposal, were accomplished in 2000:

Inventory Steering Group Development

An inventory steering group, comprising staff from Yosemite and from Sequoia and Kings Canyon National Parks (also representing Devils Postpile NM) as well as the Yosemite USGS Biological Resources Division (BRD) Field Station, was assembled and met regularly in person or by conference call through the summer and fall. This group, chaired by Dr. David Graber (Sr. Science Advisor, SEKI), was loosely substructured by subject specialties:

Vertebrate Animals: Les Chow, Steve Thompson, Harold Werner, Rachel Mazur
Vascular Plants: Sylvia Haultain, Peggy Moore, Sue Fritzke
Information Management: Pat Lineback, Joe Meyer
Consultants: Jerry Mitchell, Nate Stephenson, Jeff Manley, John Austin, Linda Mutch

Accomplishments

Although a workshop "designed to identify existing gaps, establish priorities for inventories, develop basic inventory design strategies, develop the framework for completing a written study plan, and begin developing the strategies needed for a Vital Signs Monitoring Program at all of these parks" (Pre-proposal 1999) had originally been intended for spring, 2000, after much consideration the steering committee elected not to hold it. In lieu of a formal workshop, interviews with selected subject matter experts were conducted and round-table discussions held with park and BRD staff. This decision was made in the interest of efficiency, as Sierra Nevada Network staff have given much consideration to the inventory needs of the network parks over the past two decades. Information gathered at the SEKI vital signs workshop also served to inform this process.

Vertebrate animal and vascular plant species lists for all units of the network were compiled and entered into NPSpecies datasets. Existing occurrence records for animals, and herbarium records for plants, were entered for SEKI. In 2001, this will be done for YOSE and DEPO.

A search was made for vertebrate voucher specimens in museums across the country. Six institutions have been identified, and full or partial draft lists of specimens obtained from three of these so far. In 2001, a database of specimens will be compiled, and an analogous process initiated for plant specimens.

At SEKI, many databases containing information about flora and fauna were identified and documented, with copies centrally archived. YOSE and DEPO will begin documenting and archiving data beginning in FY2001. The Dataset Catalogue will be used as the metadata documentation tool.

A survey of taxonomically problematic caudate amphibians (e.g. *Batrachoseps* spp., *Taricha* spp.) was initiated, and will be completed in the coming winter and spring.

Field crews were sent to under sampled and unique vegetation types, and data are being processed. A contract was initiated for development of a list of potential special status plant species and the design of survey strategies to locate them in the network parks.

A network web page designed to serve information about natural resources as well as the inventory and monitoring process itself is in development. Key documents and databases will be made available for

internal staff use, agency partners and the public. Design and formatting will be consistent between parks and will conform to existing NPS standards and guidelines.

Updated NRBIB entries were completed for both YOSE and SEKI.

A Sierra Nevada Network file structure standard was developed for storing data and documents and for use in a client-server environment.

The ArcView NPS Theme Manager was Beta tested at SEKI during August, 2000. The Beta test was very successful and SEKI began deploying the Theme Manager in late fall, 2000.

The information portal application ***Synthesis*** was successfully beta tested at SEKI and implementation begun at SEKI. DEPO and YOSE will implement at a future date.

A feasibility study for developing a Data Management Plan for the Sierra Nevada Network was completed. It was concluded that it was inefficient for develop a DMP from scratch, as opposed to adapting one to local conditions that was developed for the system-wide NPS Inventory and Monitoring Program.

SECTION 2 - CURRENT INFORMATION ASSESSMENT

2.1 Existing Information

Vascular Plants

Sequoia and Kings Canyon National Parks. The first comprehensive checklist of the vascular plants of Sequoia and Kings Canyon National Parks was compiled by Stagner in 1951. Based largely on collections made by the eminent botanist John Thomas Howell from 1940 to 1950, that early list included 83 plant families and 1159 taxa. In 1969, Rockwell and Stocking published a revised and annotated *Checklist of the Flora, Sequoia and Kings Canyon National Parks*, which included 2175 taxa within 120 families. This expanded list included not only those species with documented occurrences within the parks, but also those that were likely to occur, based on range data presented in the comprehensive statewide flora of the time (Munz 1965, 1968). This list is thus considered a checklist of the potential flora of SEKI. Norris and Brennan (1982) conducted surveys for 30 high priority sensitive plant taxa known to occur in SEKI. Their work included examining vouchers held in collections at Rancho Santa Ana, California Academy of Sciences, University of California at Berkeley, Davis, and Los Angeles, Fresno State University, San Jose State College, Stanford University, and the Jepson Herbarium at Berkeley. In 1984, Norris revised the checklist of Rockwell and Stocking to include only those taxa with known, documented locations within the two parks. This reduced the number of taxa to 1243 within 95 families. His work included thoroughly examining each collection held in the SEKI vascular plant herbarium, confirming determinations and annotating each specimen according to the current nomenclature of the time, which was that of Munz (1965, 1968).

The more conservative list of Norris formed the basis for the current checklist, developed by Graber et al. as part of the Natural Resource Inventory (NRI) begun in 1985. Building on the works of Stagner, Rockwell and Stocking, and Norris, Graber and his colleagues conducted further literature reviews and limited searches of outside herbaria for documented additions to the flora. This current list contains 1495 taxa in 107 families; 194 of these, or 13%, are non-native. Nomenclature has been updated to that of Hickman (1993). Voucher specimens for 1255 taxa (or 84% of the total known flora) are housed in the park herbarium. Another 195 taxa are represented by vouchers residing in outside herbaria, bringing the total number of vouchered taxa to 1450 (or 97% of the total known flora).

Completeness. Over the past two decades, several investigations have contributed significantly to our knowledge of the parks' flora. Halpern (1985) encountered 12 previously undocumented taxa in his study of hydric meadows within Sequoia National Park, 11 of which were graminoids. Stephenson (1986) added another 13 taxa to the flora while establishing over 200 vegetation plots in Sequoia National Park. Between 1985 and 1995, the NRI encountered 70 new taxa through the establishment of over 600 plots (Graber et al. 1993). Based on a systematic random sampling design, this inventory proved a powerful tool for detecting new species and provided important information on the distribution and abundance of vascular plants in the two parks. However, the grid-based design tended to undersample linear and less common features, such as riparian corridors, small wetlands, roads, and trails, which are often important centers of diversity. When the USGS initiated a survey of non-native vascular plants in 1996, search efforts were focused on such areas, with an emphasis on those that had been disturbed and had a high likelihood of harboring non-native plants. As a result, 148 taxa were added to the checklist, of which 96 were non-native, demonstrating the effectiveness of such directed surveys in encountering new taxa.

Together with the efforts of several individual botanists, 252 taxa in 59 families have been added to the flora since the publication of Rockwell and Stocking's list. Of these, 121 are not native. Not surprisingly, twenty-nine percent of the new encounters are members of the Poaceae or Cyperaceae, which are

traditionally under-detected during botanical survey work. Nearly all of the recently encountered taxa (223, or 88%) are herbaceous in form.

There are a number of ways to approach the question of completeness of a species list, none of which provide a high degree of confidence. One method is to assess the known, or actual flora against an anticipated, or potential flora. In the case of Sequoia and Kings Canyon, such a flora has been developed through the work of Rockwell and Stocking (1969). Their list of 2175 taxa represents a first estimate of what vascular plants might be expected to occur within the parks, based on published distribution data (Munz 1965, 1968). Sixty-nine percent of that list has been encountered in the parks to date, suggesting that as many as 680 taxa may remain to be found within the park boundaries.

Applying parametric and non-parametric models (species abundance curves, species-area curves, and jackknife models) to a subset of the Natural Resource Inventory data (Haultain 1992) generated estimates of total richness ranging from 1013 (+/- 987) to as many as 2,435 species, with most estimates falling near 1200. With one exception, all of the predictions underestimated total richness when compared with the known flora at that time of 1393 species. These predictive models suggest that we have encountered anywhere from 58% to 138% of the total flora.

Subject matter experts familiar with the parks and the Sierran flora find these figures difficult to accept. Local botanists agree that we are most likely to encounter 150-250 additional taxa as search efforts are increased. If correct, this would suggest that our current knowledge of the vascular flora is closer to 86-90% complete.

Devils Postpile National Monument**.** Our knowledge of the flora of Devils Postpile National Monument comes primarily from surveys conducted by Dr. Joseph Medeiros and Sandra Morey of Sierra College during 1974-1980. Their unpublished list of vascular plant species at Devils Postpile National Monument includes 235 taxa (Medeiros 1996). The monument herbarium houses 344 specimens representing 179 taxa, or 76% of the known flora. According to local subject matter experts Jim Shevock and Dean Taylor, no other botanists are known to have collected extensively within the monument, and searches at several major California herbaria have resulted in no significant collections (Medeiros, personal communication).

Based on the small size (318 ha, or 796 acres) and relative accessibility of the monument, along with the completeness of the survey work done by Medeiros and Morey, we are confident that approximately 90% of the non-graminoid taxa have been documented for the monument (Medeiros, personal communication). Dr. Medeiros estimates, however, that there are another 50 species of grasses, sedges and rushes that remain to be identified. If this is the case, our knowledge of the total vascular flora of DEPO is estimated to be approximately 82% complete.

Yosemite National Park. Hall and Hall (1912) reviewed collections made in 1909 and 1911 by Willis Linn Jepson and collections made in 1911 by Le Roy Abrams as well as those reviewed by K. Brandegee (1891) and J. W. Congdon (1891, 1892). Their *Yosemite Flora* listed 743 species for the park in 99 families; several groups were not treated at the species level (e.g., *Carex*). Botti (1992) surveyed potential habitat for rare species and documented a number of species at the limit of their elevational or latitudinal ranges as well as the presence of four state-listed species. Botti (1995, In press) reviewed collections at regional herbaria, including California Academy of Sciences; Jepson/University of California, Berkeley; U.C. Davis; San Jose State University; and Yosemite National Park Herbaria. He made additional collections in the mid-1980s and into the 1990s, altogether compiling a list of over 1300 plant species with documented occurrence in the park. This list includes 1427 taxa in 106 families, approximately 98% of which are based on voucher specimens. Exceptions include a handful of species based on reports from noted botanists who

were intimately familiar with the local and regional flora, including Dr. Carl Sharsmith and John Thomas Howell (1944).

The U.S. Geological Survey conducted exotic plant surveys in 1998 and 1999 (Gerlach in press), largely in disturbed areas, and added 50 confirmed species to the park list. Specimens from these surveys have yet to be cataloged and accessioned into the park herbarium and entered into NPSpecies and ANCS+.

Completeness. In the interest of both time and accuracy, we relied on expert opinion rather than theoretical models to estimate the percent of total species richness currently documented by voucher specimens for Yosemite. Stephen Botti has worked on documenting the Yosemite flora from voucher specimens for over 20 years. His estimate is 99% for completeness of the documented flora.

Vertebrate Animals

Existing sources of information include 3 faunal inventories conducted by the California Academy of Sciences (CAS), Smithsonian Institution National Museum of Natural History (NMNH), and the Museum of Vertebrate Zoology (MVZ) between the mid-1800s and early 1900s. The CAS and NMNH inventories consisted of brief forays into the parks to collect specimens as part of more extensive areawide surveys. The MVZ efforts systematically sampled along elevational transects across the parks over a period of several years. The MVZ surveys resulted in two publications, Animal Life in the Yosemite (Grinnell and Storer 1924) and Birds and Mammals of the Sierra Nevada (Sumner and Dixon 1953). Animal Life in the Yosemite included brief life histories for just over 90 percent of the native vertebrate fauna currently known to occur in Yosemite. Birds and Mammals of the Sierra Nevada also provided short life history accounts and included information on park status and records (including museum specimens) for 245 species known to inhabit Sequoia and Kings Canyon National Parks.

More recent sources of information for Yosemite fauna include reports and papers from studies on individual species such as great gray owls (Reid 1989), Sierra Nevada bighorn sheep (Chow 1991, Moore 1992), black bears (Graber 1982, Keay 1990), mountain lions (Chow in prep) and mountain beavers (Todd 1989). Information also exists for species assemblages such as forest carnivores (Chow in prep.) and entire taxa such as ranid amphibians (Fellers 1999, 1997, 1994), bats (Pierson and Rainey 1996), and birds (Burton et al. 1993a, 1993b; DeSante et al. 1996a, 1996b,1998, 2000; Siegel and DeSante 1999, 2000).

Recent sources of information for Sequoia and Kings Canyon include, for birds, MAPS banding data by the Institute for Bird Populations from 1991-1993, and recent studies in selected meadows (1999-2000). California spotted owls were surveyed and monitored extensively in both parks throughout the 1990s by the U.S. Forest Service; this produced additional data on other nocturnal bird species. For amphibians, extensive anuran surveys were conducted in most parts of Sequoia and Kings Canyon National Parks during the 1990s (Knapp and Matthews 2000, Fellers 1997, 1994, NPS files); in many locations this also included recording presence and identity of fish species. Limited and local surveys of caudate amphibians were conducted in 1999 by the Museum of Vetebrate Zoology. Some informal reptile surveying was conducted by Fellers during the course of anuran surveys in the 1990s, but that is the extent of contemporary reptile work. Small terrestrial mammal detection and density studies were conducted in the 1980s and 1990s by National Park Service staff at several low and mid-elevation sites. In addition, the U.S. Forest Service conducted a one-year survey for meso-carnivores in Sequoia National Park (1999).

Much less information exists for the vertebrates of Devils Postpile National Monument. In 1994 and again in 1998, the riparian resources of DEPO were inventoried for fishes, aquatic macroinvertebrates, and amphibians by the California Department of Fish and Game (Rowan et al. 1996).

Additional information on species occurrence is contained in faunal databases maintained by the individual parks. The faunal databases consist of vertebrate wildlife observation records assembled from a variety of sources, including park administrative records, the literature, park staff, and visitor reports. The Yosemite Faunal database currently contains more than 10,000 records while the Sequoia and Kings Canyon database includes more than 58,000 observations. Although the quality of this data is somewhat variable, the vast majority of observations by park staff, recognized experts, and experienced observers are considered reliable.

Based on the existence of 3,648 voucher specimens at MVZ and exhaustive research by Gaines (1988) on the birds of Yosemite, we are fully confident that Yosemite has documented evidence for well over 90 percent of the expected vertebrate species in the park. We consider the present species list to be at least 95% complete for resident and regularly visiting vertebrates.

Based on the existence of more than 1,125 voucher specimens at MVZ and others at the California Academy of Science and the Los Angeles County Museum of Natural History, we believe that Sequoia and Kings Canyon have documented evidence for more than 90 percent of the vertebrate species present in the parks. We consider the present park species list to be at least 95% complete for resident and regularly visiting vertebrates, based on the addition of only casual and newly-described species to fauna records in the past 20 years. However, when the Parks' vertebrate animals are broken down into major taxanomic groups for each network park, we find a confirmed occurrence of less than 90% for fish, amphibians, reptiles, mammals and birds in one or more network parks (see section 6.5).

Additional specimens from parks in the Sierra Network are known to be included in the collections of the Smithsonian Institution, Peabody Museum (Yale University), and the Natural History Museum of Kansas University.

2.2 Additional Work to Complete the Information Assessment

Vascular Plants

The Sierra Nevada Network parks support a remarkably rich vascular plant flora, in part due to the environmental heterogeneity created by long gradients in elevation and latitude, diverse geologic substrate, and the influence of adjacent floristic provinces. The region has been a focus of botanical interest and investigation since the early biological surveys of the 1860s, which has resulted in a relatively well-known and documented flora. As discussed in section 2.1, checklists documenting the vascular plant flora exist for each of the Network parks.

In order to bring these existing lists up to current National Park Service standards, the following tasks will be completed:

1. Complete documentation of voucher collections held in non-NPS herbaria for Yosemite National Park (section 6.6, Vascular plant species list documentation for Yosemite National Park).
2. Annotate the Yosemite checklist to include information on voucher location (section 6.6, Vascular plant species list documentation for Yosemite National Park).
3. Document Sharsmith voucher collections from Devils Postpile held at San Jose State University Herbarium (section 6.6, Vascular plant species list documentation for Yosemite National Park)
4. Convert the Devils Postpile checklist to digital, MSAccess database format (section 6.2, Vascular plant inventory of Devils Postpile National Monument).
5. Annotate the Devils Postpile checklist to conform to current nomenclature (section 6.2, Vascular plant inventory of Devils Postpile National Monument).

6. Annotate the Devils Postpile checklist to include information on endemism, life form, and location of voucher specimens (section 6.2, Vascular plant inventory of Devils Postpile National Monument).

Vertebrate Animals

Data on museum specimens collected from the parks in the Sierra Network needs to be collected from several remaining institutions. This can be accomplished through correspondence where data are not available on the Internet.

Several thousand museum specimen records in a variety of formats (usually text) will have to be compiled into Access datasets compatible with NPSpecies.

For Yosemite and Devils Postpile, historic scientific documents need to be searched for fauna records, and these compiled into Access datasets compatible with NPSpecies.

2.3 Documenting and Organizing Existing Non-Spatial Inventory Data

The Sierra Nevada Network recognizes the importance of collecting data in a scientifically credible manner so that they can be used to address current and future management issues. Existing information on vertebrates and vascular plants within the four Sierra network parks are often not well-organized or inaccessible to parks' staff. This information includes documents, databases, spreadsheets, metadata, and geospatial layers. Much of the geospatial data is better organized and accessible because of the need to distribute these data to organizations and individuals both within and outside the NPS organization. Some of these data and metadata are now available through the NPS GIS clearinghouse. However, until recently, most staff have managed and maintained their own project databases with little oversight and accountability on metadata, storage, and retrieval activities. Institutional memory has been relied upon far too heavily as a means for managing information.

Beginning in the summer of 2000 and using inventory funds, we focused on numerous tasks aimed at improving our ability to organize, maintain, and present data. Work has focused on a) NPSpecies, b) Dataset Catalogue, c) NRBib Database, d) ArcView Theme Manager, e) Development of a Standardized File Structure, and f) Synthesis. Clear objectives have evolved from these efforts including a general data management workplan with strategies. These are outlined later in section 5.0, Data Management.

During the summer of 2000, several SEKI staff looked at the potential to develop a Data Management Plan (DMP) using existing NPS guidelines. We determined that these national guidelines are outdated and the NPS currently lacks a park DMP model. Although the Sierra Nevada Network Preproposal promised to develop a DMP, we decided that it wasn't feasible to develop our own guidelines for a DMP and that leadership at the national level is needed to develop appropriate DMP guidelines and standards. Although some DMP elements have been incorporated into this Biological Inventory Plan, we decided no DMP would be developed until useful national guidelines and standards are developed and available.

NPSpecies

The I&M Program has been developing a species database, called NPSpecies, to document the present, past, or probable occurrence of vertebrates and vascular plants in NPS units. Within the Sierra Nevada Network, species lists and occurrence data have been entered into NPSpecies for all four parks. Some voucher information has been acquired from the Automated National Catalog System (ANCS+) park databases and it has been converted to the NPSpecies format. Many species with nomenclature that

conflicted with the **I**ntegrated **T**axonomic **I**nformation **S**ystem (ITIS) taxonomic nomenclature have been corrected. Entry of species occurrence records is not complete and much "evidencing" remains to be done.

Dataset Catalogue

The I&M Information Resource Dataset Catalog is an MS-Access database system in which NPS units may record the existence and availability of all types of resource data. The Dataset Catalog documents abbreviated metadata about a variety of data sets--from physical files and photographs to digital scientific and spatial data. The NPS I&M program is currently porting the MS Access program to the Internet. This Intranet Internet-based system will allow NPS units to maintain their own individual catalogs as well as browse servicewide data.

At SEKI, an intern spent significant time archiving and documenting many databases that are "owned" by individual specialists. Because the Dataset Catalogue is in Beta testing, it was not used as a metadata capture tool. These databases were documented in Word documents and will have to be captured using the Dataset Catalogue once it is formally released. Due to time constraints, no new database archiving and documentation have been completed for either YOSE or DEPO. This is a significant and important activity that will continue to be worked on for the next several years.

NRBib Database

NRBIB is a set of annotated bibliographies of park-specific natural-resource information, especially park document holdings, that have been completed by the I&M Program for each of about 250 National Park System units. This effort is an extension of the original Procite database completed in the mid-1990s. Total entries for the four parks as reported by NRBIB are 5545. The NRBIB Procite database is continually updated by SEKI and YOSE or USGS field station staff. Updated entries were recently completed for both YOSE and SEKI. DEPO has a relatively small collection of known reference work of 77 entries that is infrequently updated.

ArcView NPS Theme Manager

The NPS Theme Manager allows users to create lists of themes that are relevant to particular projects, areas, or management issues. It catalogues the themes, so that a user simply selects a theme from a pop-up list and the Theme Manager adds it to a view with a descriptive title, displays it with a legend, adds hotlinks or help files, and links to metadata. Using ArcView, the Theme Manager is an extremely efficient method for staff to access geospatial data and metadata. The Theme Manager was Beta tested at SEKI during August, 2000. The Beta test was very successful. SEKI will begin deploying the Theme Manager in late fall, 2000 and 2001 and YOSE will implement in 2001. DEPO will not require the Theme Manager until nationwide licensing and distribution of ArcView occurs in 2002 (planned).

Standardized File Structure

During the summer of 2000, it became apparent that it was essential to have a standardized file hierarchy for managing and storing data. Some of the data utilization software such as ArcView NPS Theme Manager and Synthesis require establishment of links to data or themelist files. These data files and their associated directory paths must be fairly static or it will cause problems with software linking to this data, particularly if data are frequently moved. Unfortunately, there is no national guidance or standards for data file hierarchies, so we have developed our own standard that will be used within the Sierra Nevada Network. Significant time and effort have been spent developing a standard that will meet the needs of these parks. Appendix B is the current draft file structure that will be used on one or

more servers as a means to store and manage data. The new file structure hierarchy has been established on several servers at SEKI and data transfer to populate the new file structure is nearly complete. A file structure, standardized where possible with the one established at SEKI, will be developed and implemented during 2001 and 2002 at YOSE.

Synthesis

Synthesis is an information portal for providing easy access to documents, Internet addresses, databases, images, and GIS projects. It also has keyword search capabilities and can be Web-enabled for remote access by staff not on a Local Area Network. This software is intended to make staff more efficient and effective by providing access to information they need for managing natural resources. Synthesis is an NPS software product that is currently in Beta version and is still under development.

In June 2000, Synthesis was successfully beta tested at SEKI by the software developer and the NPS Synthesis project manager. Even though the current version has some shortcomings, SEKI made a decision to complete a limited deployment of Synthesis and provide access to key documents, databases, images, and GIS projects. Interface templates to access key information have been developed at SEKI and final deployment will occur when the Standardized File Structure project has been completed in fall, 2000. DEPO has installed Synthesis on one workstation and will complete a limited deployment of Synthesis in 2001. YOSE is emphasizing completion of NPSpecies, Dataset Catalog and GIS Theme Manager prior to efforts aimed at deploying Synthesis.

2.4 Documenting Existing Spatial Data

Table 1 is a summary of current GIS data availability for the Sierra Network Parks. This table is intended to provide only a “thumbnail” overview of current data availability. These data are digitally available in a variety of formats in a variety of locations. SEKI has placed some of these data on the NPS data clearinghouse including posting FGDC compliant metadata. Data accuracy is highly variable and FGDC compliant metadata is available for some, but not most of these data.

Table 1. Summary of GIS data availability for Sierra Network Parks

GIS Layer	DEPO	SEKI	YOSE
Boundary	X	X	X
DOQQ's	Partial	X	X
DRG		X	X
Fire History	X	X	X
Fuels		X	X
Geology		Partial	X
Hazard Trees		Partial	
Herp Fauna Distribution			
Hydrology	X	X	X
Hypsography		X	Partial
Mammal Distribution			
Monitoring Sites		X	
Roads	X	X	X
Sensitive Animals Distribution		Partial	
Sensitive Plants Distribution		Partial	Partial
Soils		Partial	In-Progress
Structures		X	Partial
Topography		X	X
Trails	X	X	X
Utilities	Partial	Partial	Partial
Vegetation	X	X Revision In-Progress	X Revision In-Progress
Wildlife Occurrences		X	Partial
Exotic Plants		Partial	Partial

SECTION 3 - IDENTIFICATION OF INVENTORY NEEDS

3.1 Setting Network Priorities

During a series of conference calls and meetings, YOSE and SEKI Natural Resource Management and USGS-BRD staff discussed the status of vascular plant and vertebrate inventories for the four parks. Input from additional, outside experts was solicited regarding completeness of existing inventories. Searches were made of existing voucher collections to assess the completeness of outside collections and complement the expert opinion. Park and USGS staff then identified data gaps in existing inventories, and established the following criteria for prioritizing projects (in rough priority order):

-Vascular plants and vertebrates
-Paucity of information
-Species of management concern (sensitive and exotic species)
-Cost effectiveness
-Partnership potential (non-profits, etc.)
-Feasibility for monitoring
-Potential indicators of environmental change

Following these initial discussions, the vascular plant and vertebrate groups developed proposals designed to address these identified data gaps. These proposals were then placed in priority order according to the above criteria.

During these initial discussions, data management was discussed at length. It was agreed that funding "off the top" should be set aside for data management: the "care and feeding" of data (including legacy data); data documentation (both existing data and data developed through the I&M program); data access; dataset integration; and quality assurance through appropriate standards and protocols. Accordingly, a Network Coordinator/Data Manager will be hired to oversee program data management, although low level data management (data entry, etc.) is incorporated into individual project proposals.

The four parks placed high priority on the need for a network coordinator who could devote more time to coordinating and facilitating network activities. We chose to integrate the network coordination and data management responsibilities into one GS-11 term position. Please see Section 7.2 "Network Coordination" for details on how network coordination will be managed.

For vascular plants, the paucity of data on special status vascular plants at all parks led to work targeting these taxa receiving the highest priority (see section 6.1). A baseline inventory of vascular plants at DEPO will include surveys for plants of special concern (see section 6.2).

Paucity of information on vertebrate species led to the development of 10 "strawman" project proposals. After discussion of these project proposals in relation to the criteria, the YOSE, SEKI and USGS staff prioritized these 10 proposals for the network parks. All parks had high priority need for information on reptiles and small mammals, and these project proposals were combined into a single proposal that focused on an interdisciplinary team approach. Bats were identified as a high priority need, due to the number of bats that are special status species, and a bat proposal for work at SEKI and DEPO received a high priority in order to bring these parks into parity with YOSE. Exotic plant distributions have been somewhat addressed for SEKI but are poorly understood for certain environments at Yosemite. See section 6 for a projection description to document the distribution of exotics in areas of natural disturbance at Yosemite.

List of Projects by Taxa

Based upon the process and criterion described above, the following lists were developed.

Vascular Plants. Proposed projects to complete inventories of vascular plant taxa in the Sierra Nevada Network parks are listed below in priority order.

1. Vascular plant surveys, including graminoids, non-native, and special status plant taxa within Devils Postpile National Monument

2. Special status vascular plant surveys within Sequoia, Kings Canyon and Yosemite National Parks and Devils Postpile National Monument
   - Compile comprehensive list of special status taxa
   - Design survey strategy for special status taxa
   - Develop habitat-based models of predicted distribution of state and federally listed taxa
   - Conduct surveys for special status taxa

3. Vascular plant species list documentation for Yosemite National Park

4. Distribution and abundance of exotic plants in areas of natural disturbance in Yosemite National Park

Vertebrate Animals

1. Distribution of bats in Sequoia and Kings Canyon National Parks and Devils Postpile National Monument

2. Terrestrial and aquatic vertebrate survey in SEKI, YOSE and DEPO

3.2 Species of Special Management Concern, by Taxa and Park

(Note that this section refers to species of special management concern, including sensitive and exotic species, and should not be confused with the term "species of special concern", a term that is an official category of species under the California Endangered Species Act, as described in Appendix E.)

Vascular Plants

Sequoia, Kings Canyon and Yosemite National Parks. Surveys targeting special status plant species were last conducted in Sequoia and Kings Canyon during the early 1980s by Norris and Brennan (1982). Although surveys for known or suspected special status plant species were conducted in both parks, they were largely limited to trail corridors within Sequoia and parts of Kings Canyon; much of northern and central Kings Canyon remain unsurveyed. Norris and Brennan produced a detailed two-volume report containing references, site locations, habitat descriptions, color photographs and slides, and line drawings of 32 species. Currently, forty species of sensitive vascular plants are known to occur within the two parks (see Appendix E). Of these, two are state-listed as rare, and California Environmental Quality Act (CEQA) consideration is mandatory for two others. CEQA consideration is recommended for an additional fourteen taxa. The remaining twenty-two taxa have no state or federal status, but are considered sensitive because they are rare, endemic, endangered or of limited distribution in California. An additional fifteen are known to occur on lands adjacent to the parks; these are kept on a watch list as they are suspected of occurring within the park boundaries as well. An MS Access database and Arc View coverage of all known occurrences of these taxa in Sequoia and Kings Canyon National Parks was developed in 1999.

Fairly broadscale surveys for special status plant species were last conducted in Yosemite in the mid-1980s by park Resources Management staff. These surveys were done without project funding and were largely limited to the most accessible areas of the park. They resulted in field reports that provided locations, site and population descriptions, associated species and photographs or line drawings. Based on that work, 108 species of special status vascular plants are recognized within the park (see Appendix E). Of these, five are federal species of concern, four are state-listed as rare, 37 are listed by the California Native Plant Society, and 99 are listed by the park as rare due to endemism or limited distribution within the park. A relational database and GIS coverage of all mapped occurrences were developed in 1991.

A contract to develop a complete list of the special status plant species of Sequoia, Kings Canyon and Yosemite National Parks and Devils Postpile National Monument was awarded to the environmental consulting firm of Jones and Stokes in September of 2000. In addition to developing a list of taxa both known and expected to occur within the Sierra Nevada Network parks, investigators will develop habitat-based models of the predicted distribution of high priority species, and a sampling strategy for completing surveys for special status plant species. Upon completion of this work, surveys will be conducted within the Sierra Nevada Network parks to document the distribution and abundance of high priority special status plant species. See section 6.2, this document, for a detailed description of these projects.

Non-native plants. Prior to 1996, surveys of exotic plants were limited to data collected from systematically-located inventory plots in Yosemite, Sequoia and Kings Canyon, which tend to undersample linear landscape features such as stream and road corridors, common avenues for introduction of exotic plants. To supplement the inventory plots, in 1996, the Biological Resources Division of USGS initiated directed surveys in habitats likely to harbor introduced species, such as riparian corridors, developed areas, roads and trails, pack stations, campgrounds, abandoned settlements, sewer spray fields, and other disturbed areas. Emphasis was placed on locating all exotic taxa in these targeted habitats. Once located and identified, populations were mapped, abundance was estimated and local distribution was described. Field surveys were completed in Sequoia and Kings Canyon in 1998, in Yosemite in 1999.

Field surveys are being followed by the creation of a comprehensive data base consisting of autecological information for each species (summarized from available literature) and themes within a geographical information system (GIS) showing documented occurrences. In addition to providing maps of the known range of each species, the GIS database can be used to analyze how species distributions correspond to geographic factors (topography, geology, hydrography, vegetation types), incidence of vectors (visitation rates, stock use, construction), management factors (prescribed fire), and climatic factors (precipitation distribution and abundance). The final step of this research, and that of most interest to resource managers, will be to rank the management and control priority of each species using the system developed by Hiebert and Stubbendieck (1993). This system ranks species according to their innate ability to become pests (based on such factors as reproductive potential, germination requirements, dispersal ability, mode of reproduction, and competitive ability) and the current level of impact (current distribution and abundance of plants and propagules within and adjacent to Park boundaries). This ranking is then weighed against the feasibility or ease of control. The result gives managers an objective set of decision-making criteria for where to focus their management and control efforts: on those species most likely to infest natural habitats and displace native plants, that can also be effectively controlled. This ranking will be completed early in 2001.

Vascular Plants of Devils Postpile National Monument. No dedicated surveys for special status or non-native plants have been conducted to date within Devils Postpile National Monument. Beginning in 2001, a team of two botanists will be stationed at the Monument to carry out surveys for special status, non-native, and graminoid taxa (see section 6.1, this document).

Vertebrate Animals

Sequoia, Kings Canyon and Yosemite National Parks and Devils Postpile National Monument.

Native Vertebrate Species of Special Concern

Vertebrate species of special management concern include those that are listed as either: threatened and endangered, sensitive, or otherwise at risk of being lost from the park fauna. Some species of animals have undergone local, state, and/or national declines, which raise concerns about their possible extinction if protective measures are not implemented. As a result, such species have been given special state or federal legal status that enables agencies to provide greater protection and implement actions to restore their populations. A glossary of recognized federal and state listing categories is included in Appendix E.

Potential extinction of special-status species represents the greatest immediate threat to biological diversity in the Sierra Nevada Network parks. Some species are listed because they naturally have very limited distribution (e.g. Mount Lyell shrew). The tenuous status of a majority of the listed species is, however, the result of regional or even national human-caused effects, usually in the form of habitat destruction. Although the Sierra Nevada Network parks offer refuge for many of these species in the form of relatively intact habitats, their populations in the parks are influenced by isolation and altered rates of immigration from adjacent areas.

Special-status vascular plant and vertebrate wildlife species that are formally recognized either through a rulemaking or agency designation and that are known to occur in the Sierra Nevada Network parks are listed in Appendix E**.** Because of their status, recent presence of a majority of the listed special-status animal species in the Sierra Nevada Network parks is known through studies that focussed on individual species or taxa, surveys conducted in association with park projects, or reliable observations by staff and visitors. For these reasons, no special-status species, except the Mount Lyell shrew (*Sorex lyelli*), are targeted for presence-confirming surveys. The Mount Lyell shrew is targeted, along with a number of non-special-status species, because there are no recent records of this species (see Section 6.5). The California wolverine (*Gulo gulo luteus*) and the Sierra Nevada red fox (*Vulpes vulpes necator*) also fall into this seldom-seen category, but their extreme scarcity makes it unlikely that even extensive surveys, which are not feasible under the current budget, would reveal their presence.

Please see **Appendix E,** for definitions of the various federal, state and National Park Service categories.

Exotic Vertebrate Species of Special Concern

Wildlife: There are more than a dozen non-native vertebrate species known to occur in Yosemite, Sequoia and Kings Canyon National Parks. The introduced species of concern include fish, birds, mammals and only one amphibian. We know nothing about introduced invertebrates. Some of these exotic species are thought to have marginal effect on native species, while others are known to have a profound effect.

Non-native Fish. Rainbow, brook, and brown trout have been widely planted in the parks to support recreational fishing. These introductions have mostly occurred in lakes and streams that were naturally without fish, and have likely had a serious effect on native populations of invertebrates and amphibians. This is especially true for the mountain yellow-legged frog (*Rana muscosa*) which is likely to be soon listed as Federal threatened or endangered due primarily to the effects of introduced fish.

Bullfrogs (*Rana catesbeiana*)**.** Bullfrogs are widespread in Yosemite Valley and are present in several lakes in the northwest part of the park at approximately 6,000 feet elevation. They are also widespread in lower elevations in Sequoia National Park. Bullfrogs are known to prey on a wide variety of taxa, including insects, amphibians, reptiles, birds, and small mammals. California red-legged frogs (*Rana*

aurora draytonii), a Federal threatened species, are thought to have occurred in Yosemite Valley, and were last recorded in the park in one of the lakes now occupied by bullfrogs. California red-legged frogs are no longer found in Yosemite, and bullfrogs were likely one of the major factors in their extirpation. Native western pond turtles, *Clemmys marmarata,* are destroyed by predation from introduced bullfrogs in lower elevation drainages of Sequoia National Park

Wild turkeys (*Meleagris gallapavo*). Wild turkeys are known to occur in several areas along Yosemite's western boundary and Sequoia's southwestern boundary, but their distribution in the parks is thought to be minimal. Their possible impacts on park wildlife include competition for food and support of unnaturally high predator numbers.

White-tailed ptarmigan (*Lagopus lecurus*). This species was introduced at Mono Pass in 1971-1972 by California Department of Fish and Game, and has since steadily expanded its range into alpine areas of Yosemite National Park. It also occurs in Kings Canyon National Park. The impact of this species on native ecosystems is unknown, but it could be affecting native alpine plants that grow slowly. This species also could be supporting unnaturally high predator populations.

Brown-headed cowbirds (*Molothrus ater*). Cowbirds have flourished in the habitats created by agriculture and livestock in California, and are extending their range into the Sierra Nevada. In Sequoia, Kings Canyon and Yosemite, cowbirds are present in large numbers around residential areas, campgrounds and, especially, corrals and stables. Cowbirds can have a profound effect on native bird species through nest parasitism. Recent studies of cowbirds in Yosemite and Sequoia and Kings Canyon (Haltermann et. al 1999) failed to find significant cowbird parasitism of riparian-nesting birds, but the presence of such large numbers of cowbirds, including fledglings and juveniles, suggest that parasitism is occurring in different habitats. Warbling and Cassin's vireos are especially vulnerable to cowbird parasitism, and have apparently declined in the park (Gaines 1988).

European starlings (Sturnus vulgaris) and House sparrows (Passer domesticus) . These species compete with native species for nest cavities in trees, and destroy nests in occupied cavities to gain ownership. The extent of this impact is unknown, but is limited to the lowest elevations of the parks.

Virginia opossums (*Didelphis viginianus*). These are present in low numbers in El Portal and at the western edge of Sequoia near Three Rivers, where they likely compete with native species for food and prey on others. Such effects are thought to be minimal due to the scarcity of opossums.

Wild pigs (Sus scrofa). Wild pigs are present in areas adjacent to Yosemite's western border, but are not known to occur in the park. They occasionally range into the western edge of Sequoia National Park. If their range were to extend more extensively into these parks, they would likely affect native plants and wildlife through predation and habitat destruction.

Feral Cows(Bos taurus) Cows range into the western boundary areas of Sequoia National Park in the East Fork, Middle Fork and South Fork drainages of the Kaweah River as well as in the Redwood Canyon area of Kings Canyon. Their impacts include trampling riparian vegetation, grazing and import of exotic plant seeds.

Because the presence of most non-native wildlife species in the park is known, no inventories of these species are proposed. More information is needed, however, on their distribution and ecological effects.

SECTION 4 - STUDY DESIGN AND SURVEY METHODS

4.1 Overall Sampling Framework

Vascular Plants

An overall sampling framework is important for allowing information on distribution and abundance to be extrapolated to unsampled areas. Because objectives and other concerns vary considerably by project, we separately discuss how the concept of a sampling framework applies to each project and/or park. Most of the parks in the Sierra Nevada Network have over 90% of expected plant taxa documented through voucher specimens at various institutions (see Section 2.1). Devils Postpile is the exception; however, the percentage of evidenced taxa at DEPO is estimated at a high 82%, with gaps mainly in the area of graminoids. The proportion of evidenced taxa will be increased with vouchers stemming from complete surveys of the 318 ha (796 ac) park to describe the distribution and abundance of special status and exotic plant species (see section 6.2) as well as directed searches for graminoids.

Altogether, four synergistic strategies will be implemented at Devils Postpile to bring our knowledge of the vascular plant flora up to 90%: exotic surveys, special status plant surveys, surveys specifically to fill in gaps in evidenced species and vegetation sampling designed for multiple purposes. Surveys for non-native plants will be conducted throughout the monument, with special emphasis on roads, trails, developed areas, and other disturbed habitats. Surveys both within and outside of these types of disturbance in SEKI and YOSE in the late 1990s showed a marked preponderance for exotics to establish in these anthropogenically disturbed areas. These surveys will minimize time spent in undisturbed areas where surveys have found exotics to be relatively rare in the other Sierra Nevada parks. Botanists will be able to do complete surveys of all sites so that subsampling is unnecessary.

Surveys for special status vascular plant taxa will be carried out following a sampling strategy currently being designed under contract (see section 6.1). Given the small size of the monument, botanists will be able to traverse the entire area during the course of a single field season.

Directed searches for graminoid taxa, which represent the greatest information gap, will focus on meadow and riparian environments at DEPO. The establishment of vegetation plots will augment these directed surveys. As part of the Yosemite vegetation mapping program, preliminary interpretation of aerial photography will be completed under contract prior to the 2001 field season. The resulting vegetation map will be used as part of a sampling framework for establishing at least three vegetation plots per type. Three vegetation polygons will be randomly selected per alliance or association. Plots will be randomly placed within the selected polygons with overselection of sample sites to allow for rejection of nonhomogeneous vegetation. In addition, a minimum of three plots will be placed in types encountered on the ground but not detected by the photo interpreters.

Network priorities for additional inventory work at Sequoia, Kings Canyon and Yosemite are focused on some of the least common and even rare species, namely exotics and special status plants. Because of basic differences in the factors that influence the distribution of these groups of species, each of these projects will have project-specific sampling frameworks. Stratified random sampling approaches are integrated into each. For special status plant surveys in all four parks, potential habitat will be modeled by a contractor, and inventory sites will be randomly selected from the potential habitat for each target species. The entire array of potential habitat will be visited at DEPO. For SEKI and YOSE, where sufficient potential habitat exists for a target species that it cannot be surveyed in its entirety, habitat will be stratified by elevation and survey sites randomly chosen from among elevation bands.

Exotic plant surveys proposed for Yosemite will be based on stratification of fires by ignition source (lightning or prescribed), age of fire and elevation. A grid-based approach will be used to structure survey efforts within these strata.

Vertebrate Animals

The sampling (survey) framework for terrestrial and aquatic vertebrates is based on the premise that in large wilderness parks, it is most efficient to combine surveys or searches for a variety of taxa at the same general locations.

The survey will initially employ targeted searches to determine presence/absence for network priority species. Targeted searches will involve sampling historic locations and preferred habitats to maximize the efficiency and likelihood of detecting species occurrence. The preferred habitats for network priority species will be determined from a search of the literature. We will map the distribution of preferred habitats using the parks' GIS and sample a selected unbiased subset of those habitats, seeking to optimize for sampling economy yet broad geographic distribution. This approach to sampling is based on the principle that a completely random sampling design will yield extensive unbiased information on common taxa but inadequately detect network priority and rare species. Although the primary objective of this approach is a rapid assessment of presence/absence for priority species, it does not preclude collecting information on more common taxa captured incidentally.

4.2 Habitat Strata

Once presence has been established for network priority species, we will expand sampling efforts to incorporate a stratified random design using vegetation as the basis for site classification and selection. The objective of this effort is to gather information on the geographic distribution and relative abundance of priority vertebrate species inhabiting the parks. The distribution of sites will be roughly proportional to the occurrence of each vegetation type within each park with slightly more sites in rare or uncommon habitats in proportion to their occurrence. The sites within each type will be a randomly selected subset of locations located at the intersections of a randomly placed 1 km square grid superimposed over a map of the park. In the event that a randomly selected site cannot be sampled (it is in a lake or is too steep to safely collect data), it will be rejected and replaced with another randomly chosen site.

4.3 Estimating Sample Size

At the present time, there are insufficient data on the probable distribution and abundance of network priority species to estimate sample sizes necessary for either detection, or for estimating abundance. Moreover, detectability varies greatly among the subject of interest. Consequently, it is not possible at present to estimate necessary sample size.

4.4 Voucher Policy

The scientific value of a comprehensive set of voucher specimens for vertebrates and vascular plants in a park cannot be overestimated. Such collections document the occurrence of organisms despite changes in taxonomy and provide the basis for evaluating and monitoring changes in species richness and genetic diversity. At the same time, conservation issues remind us that science activities in parks should serve to preserve species, not adversely affect them. These considerations, along with the more pragmatic ones of curatorial costs and storage requirements, were considered in developing the voucher policy of the Sierra Nevada Network.

Investigators will be required to collect adequate vouchers to document species occurrence, but extensive vouchering to document the full range of phenotypic variability will not be undertaken. Investigators must have a valid park collecting permit to collect specimens. Permission to take duplicate vouchers will be considered on a case-by-case basis by individual park resource managers. Voucher preparation will be the responsibility of inventory contractors and cooperators and must follow guidelines outlined in 36 CFR and the Museum Handbook. NPS Management Policies; NPS 77, Natural Resource Management Guidelines; and Director's Order 24 for Museum Collections will be followed while the best possible storage and curatorial arrangements are made to provide for long term maintenance and access. Voucher photographs will be deposited in individual park archives.

All vouchers taken on NPS lands, regardless of their final repository, are the property of the NPS. Sierra Nevada Network or park personnel will be responsible for cataloging voucher specimens into ANCS+. Investigators will be responsible for providing data compatible and compliant with the NPSpecies database.

Vertebrate Animals

In general, vertebrate vouchers will be taken only if they represent an addition to the documented species for the park, there are currently no accessioned vouchers in existence or they are necessary for species identification. Individual records and photographs will include vertebrate scientific name, important diagnostic features, date and location of photograph or observation and name of observer or photographer. One specimen will be considered adequate to document occurrence at a park (except where noted in Table 2). Collection guidelines for each vertebrate taxon are described in Table 2. Whenever possible, a series of photographs (rather than multiple specimens) will be used to document observed phenotypic variability. Investigators should opportunistically collect material from roadkill animals and animals killed by natural events (e.g. flood, prescribed fire) that will provide voucher quality specimens or DNA material. Voucher specimen preparation will follow the accepted standards for each taxon (Schemnitz 1980).

Vascular Plants

Investigators for plant inventories will collect voucher material of all taxa for which no vouchers exist in the park herbaria. Each park already has extensive holdings, and lists will be provided indicating current holdings for guidance. Enough plant material should be collected to cover two 39.5 X 29.5 cm herbarium sheets. Roots should be included, where possible, with care taken to leave the remaining plants undisturbed. Flowers or seeds are often necessary for identification and should be collected as available. For large herbs, shrubs and trees, parts critical for identification must be collected. Plant specimens must be protected from wilting and desiccation prior to placing in a plant press. If phenotypic variability is observed, a short series of each species may be collected, excluding rare species. For relatively common species, duplicate vouchers may be collected for deposition at a regional herbarium.

Rare Species

Because most rare species exist in very small numbers, taking of those species should be limited to situations when significant benefit to the affected species and/or meaningful new information about the species will result from the taking. For species that are listed on federal or state rare and endangered species lists, specimens shall not be taken without appropriate permits and the express permission of the park resource manager (as specified in collection permit). There will be Section 7 consultation with the U.S. Fish and Wildlife Service for any federally listed species. Photographs, sound recordings, or plant fragments should be used to document occurrence rather than taking whole specimens. In some cases

species identification cannot be made based on external characteristics; those will be addressed on a case-by-case basis. DNA analysis of samples offers another vouchering alternative. When other means of vouchering are not available, and the investigator has received permission to collect a rare species, only one voucher will be taken to document occurrence at a given park.

Locally rare species: While it is likely that more individuals of a species exist at a site than are actually observed or captured during a survey, the risk of depletion of a local population through collection is greater for a rare species than for more common species. A voucher should only be collected if at least 10 individuals of an animal species or 25 individuals of a plant species are present at a given sample site.

Table 2. Voucher guidelines for vertebrate taxa.

Taxonomic Group	*Suggested Vouchers*
Mammals	
Bats	• Wing punch or whole specimens for easily misidentified species, if capture is part of the protocol • Morphometric data, photographs, digital sonograms or cassette tapes with reference calls as evidence of rare bats
Large and mid-sized mammals	Whole specimens not necessary. Photographs or hair samples, if possible, to help document species occurrence when inventory based on tracks
Small mammals	Three of each species (1 per sex & a juvenile); skulls used to differentiate among shrew species and among rodents
Birds	Whole specimens not necessary • Visual or song identification by qualified observers (common species) • Vouchers on a case-by-case basis • Photographs, sound recordings and complete written description of unusual sightings • Complete written description following accepted AOU standards
Amphibians/reptiles	• Whole specimens if identification difficult, or if trap mortality occurs or represents an addition to park species list • Visual identification by qualified observers (common species) • Photographs, if diagnostic features clear • Sound recordings (anurans)
Fish	Whole specimens, if required for identification • Visual identification by qualified observers (common species) • Photographs, if diagnostic features clear • Photographs and complete written description of unusual sightings

Taxonomic Group	*Suggested Vouchers*
Plants	• Sufficient material for identification and enough to fill 11 x 17 inch specimen sheet • Include flowering and fruiting parts • Ensure collection is representative of plants on the site • Note location description and location coordinate, collector, date, plant description (e.g., flower color when fresh), habitat, and collector's collection number if any.
Trees	• Representative branch • A piece of bark if useful for identification • Include flowering and fruiting parts • Note plant height
Shrubs	• Representative branch • Include flowering and fruiting parts • Note plant height
Herbs	• For small plants, collect entire plant(s) including roots • For large plants, collect sections that are representative of the variation in leaves and stems. Consider sampling large plants from base, middle and upper stems • Include flowering and fruiting parts • Include underground parts with collection

SECTION 5 - DATA MANAGEMENT

Good data management is essential to developing and maintaining a successful Inventory and Monitoring Program. This section emphasizes bringing existing data up to an acceptable standard, development and management of new data, and providing staff and public easy access to data and supporting information. It is very important that this information be collected according to well-defined standards, managed to protect long-term data integrity, and be made accessible to the staff and public. This plan proposes using both existing and new staff to add emphasis and focus to existing and new data management initiatives.

5.1 Data Management Objectives for Sierra Network Parks

1. All significant spatial and non-spatial data within the Sierra Nevada Network is adequately documented and archived using appropriate methodologies, tools and technologies.

2. NPSpecies has complete vascular flora and vertebrate species occurrence lists with supporting evidence information from all available sources.

3. Access to data and supporting documentation is easy to use, readily retrievable, and well documented through use of available NPS software systems and Internet technologies.

4. Long-term integrity of data is ensured using appropriate archiving, security, and other standardized data management protocols.

5. Data collection and data handling protocols follow approved standard operating procedures, incorporate appropriate standards, and meet best science standards.

Based on these objectives, there are five elements of data management that will be emphasized: a) network data coordination and management b) archiving and documentation of existing data, c) archiving and documentation of new data, d) data collection and handling, e) making data available and accessible to the staff and public. Table 3 summarizes the inventory data development and management tasks and responsibilities scheduled for years 2000-2004.

5.2 Network Data Coordination and Management

At SEKI and YOSE, I&M data management will be based on a client-server model for distributing data and information. The number and location of data and application servers will be clarified, as individual parks' needs become clearer. Standard practices will be implemented that assure long-term data integrity and preservation. To the extent possible, management of data and application servers will use existing policies and procedures. DEPO has individual computers at two geographic locations that are not part of an NPS local area network. At DEPO and in conjunction with our Information Technology staffs, we will have to develop standards and procedures for ensuring best data management practices relating to archiving and accessing data.

A new term position GS-11 Network Coordinator/Data Manager will be created and duty stationed at SEKI and supervised by the SEKI Resource Planner. This position will require frequent travel (25% or more) to DEPO and YOSE to facilitate data management and other network activities. Two seasonal GS-07 data specialists will be hired to support data management efforts. For FY 2002 and 2003 (8-10 pay periods per year), one data specialist will be stationed at SEKI and one at YOSE. The existing Sierra Nevada Network steering committee will prioritize data management tasks and provide overall guidance and project standards compliant with established national standards and guidelines.

We highly recommend that the Natural Resource Information Division develop standard data development and management language and guidance that could be inserted into new Inventory and Monitoring contracts. This will ensure more consistent and superior data development principles and practices being followed by principal investigators.

A Data Management Plan (DMP) is a key document that is critically important for establishing guidance and standards for Sierra Nevada Network data activities including data development, data management, data access, and integration systems that use the Internet and other emerging technologies. The Sierra Nevada Network will continue to collect information as identified in previous sections. NRBib, NPSpecies, Dataset Catalogue, standardized file hierarchy, etc. are all building block elements for a successful DMP. Some business processes will be developed that provide standards and procedures for collecting and managing information. Perhaps a more appropriate term is Natural Resource Information System (NRIS). As the NRIS (DMP) guidelines are updated, we will integrate our work with any updated national guidelines or standards. Additional national guidance is needed to provide a useful integration framework for developing data, managing data, and presenting information to NPS staff, other agencies, and the public.

5.3 Archiving and Documenting Existing Data

Millions of dollars have already been spent on inventory projects resulting in a wealth of information that exists in databases, documents, and GIS layers. Beginning in summer 2000, increased emphasis has been placed on documenting existing data. Our goal is to document all important natural resource data with metadata or information about data. Important data is defined as data that has permanent value and use in describing or analyzing the natural resources either within or contiguous to the Sierra Nevada Network Parks. At a minimum, data will be documented using the Dataset Catalogue (described in Section 2.3). This work was begun at SEKI in FY 2000 and will be extended to YOSE and DEPO with the help of the GS-11 Network Coordinator/Data Manager position and the GS-07 support positions during years 2001-2003. Digital geospatial data will be documented using the FGDC Content Standards for Digital Geospatial Metadata, version 2. Our Sierra Nevada Network goal is to have Dataset catalogue or FGDC compliant metadata documentation for the 200 most important and existing databases, spreadsheets, documents, imagery, and geospatial layers by the end of calendar year 2003.

Data will be managed in a client-server environment at both SEKI and YOSE. A file directory structure standard was completed in 2000 with the purpose of standardizing the organization of documents, databases, imagery, and geospatial data in a distributed client-server environment. Appendix B presents the current file structure summary that will be used as a distributed template on one or more servers. As data are moved, staffs' GIS projects (Arcview and ArcMap) are corrupted, so it is very important this data be placed in directories with good confidence that it will be the permanent "home" for moved data. This file structure hierarchy was implemented at SEKI in 2000 and will be implemented at DEPO in 2001. Where practicable, a similar format will be implemented at YOSE in 2001. This process involves creating a complex empty file structure and then moving existing data, documents, imagery, and metadata into the appropriate directory structure.

Although initial NPSpecies data entry was completed in 2000, significant effort will be expended in 2001 on improving the Sierra Nevada Network NPSpecies databases. Although initial entries have been entered into the NPSpecies database, much additional work remains to be completed. We will find evidence information for individual occurrence records, including extensive voucher collection searches for plant and animal specimens from museum and herbarium collections. The institutions with possible voucher evidence include: California State University Humboldt; University of Arizona, Tuscon; Ownbey Herbarium in Pullman, Washington; University of Michigan in Ann Arbor; Tulane University Herbarium; the California Academy of Sciences; the University of California Berkeley, Museum of Vertebrate Zoology; University and Jepson Herbaria, at U.C. Berkeley; San Jose State Herbarium; Cal State Fresno Herbarium; University

of California Davis Herbarium; New York Botanical Garden, and the Los Angeles County Museum of Natural History. Further evidence will be collected through referencing publications or reports from the NPS Bibliographic database (NRBib) and will be completed in 2001. An Environmental Careers Organization (ECO) Intern will spend about four months working on updating the occurrence records and acquiring evidence to back up each occurrence record. Some of these data can be easily retrieved through a query of an institution's database, but in some instances may require a site visit to individual institutions. The Network Coordinator/Data Manager position will have long-term responsibility for management of the NPSpecies databases.

Nearly all of the vascular plant specimens in the YOSE Herbarium have been entered into ANCS+. The remainder will be entered during 2001-2002. SEKI Herbarium holdings have all been entered into ANCS+.

During FY 2001-2002, we will update the NRBib records for all four parks and make sure that bibliographic references are accurate. Much work still needs to be completed including finding and entering unpublished documents, quality control of existing entries, and locating and entering unpublished documents such as university theses and dissertations. The actual scope of what materials should be entered into NRBib is unclear. Although maps, photos, electronic datafiles can be referenced and documented in NRBib, it is unclear what the distinctions are for using other database systems such as the Dataset Catalogue and Technical Information Center (TIC) system. Further, no relational links exist between any of these data management systems. Current plans are to continue entering and referencing only published and unpublished materials and not focus on documenting databases, maps, or photos within NRBib. The Network Coordinator/Data Manager position will have responsibility for overseeing the update and ensuring the accuracy of NRBib entries.

5.4 Archiving and Documentation of New Data

All databases will be developed using MS Access as the standard. All reports will be submitted in MS Word format (current NPS standard is Word 97). All new information acquired during these biological inventories will be entered into the appropriate NPS databases including NPSpecies, NRBib, Dataset Catalogue, or FGDC compliant metadata. Written language will be inserted into all contracts assuring compliance and compatibility with these standards. Oversight and enforcement will be the responsibility of the Network Coordinator/Data Manager position.

The Sierra Nevada Network will use the MS Access "I&M Database Template" currently under development as a starting database structure for managing data. This I&M database is a standalone software application that can be used to enter, edit, display, summarize, and generate reports for inventory or monitoring datasets. Further, this data could be used in conjunction with the ArcView NPS Theme Manager to spatially examine specific sampling locations and any associated data. The purpose of this relational database is to leverage existing information and make it more available to staff and the public. This relational I&M database will be modified to fit the needs of the Sierra Nevada Network including incorporation of appropriate legacy data into the new database structure(s). All principal investigators will be required to provide digital databases that are consistent with the I&M Database structure. At SEKI, thirty-one permanent I&M plot databases consisting of 1138 individual plots with identified geographic locations have been normalized into a single database that is currently available to SEKI staff. These plots come from a variety of sources and have multiple purposes including: fire effects monitoring, fuels monitoring, air quality, natural resource inventory, and faunal monitoring. As a pilot test and starting point, these data will be used to populate the new I&M database structure and validate its utility.

The Network Coordiinator/Data Manager position will have responsibility for assuring that new data are captured and documented in accordance with established guidelines and standards. This includes incorporation of new data and reports into NPSpecies, NRBib, Metadata collection (FGDC metadata and

Dataset Catalogue), and archiving of data, documents, and metadata in appropriate locations. All new data developed through contract or by NPS staff will have compliant metadata developed – no exceptions. Language will be inserted in all contracts specifying metadata procedures and products. The position will also be responsible for any needed modifications to the new I&M database template to match Sierra Nevada Network needs, provide database oversight on inventory and monitoring contracts, and train staff to use and understand the I&M database application.

5.5 Data Collection and Handling

Data collection and handling will focus on the following activities: 1) building relatedness among data sets through standardized field forms, site and event codes, and habitat measures, 2) ensuring that all important field data are documented using appropriate metadata standards, 3) assuring accurate implementation of appropriate sampling methods and data collection protocols, 4) establishing measurable minimum standards for collected data, and 5) independent verification of data transcription.

The Sierra Nevada Network will develop standardized fields to ensure compatibility among data sets for all new inventory initiatives. In addition, contractors will be required to use standardized event or site codes that will be developed by Sierra Nevada Network staff. A standardized habitat worksheet will be used for all inventories to document the strata. This kind of standardization will enhance our ability to leverage existing data collection efforts with future information and analysis needs.

Data verification is the process of comparing digital data in databases with the original field form data. All principal investigators will be required to complete quality control assessments that compare a representative sub-sample of data on field forms to the digital data entered from the field forms. All principal investigators will be required to provide copies of all field data sheets with a digital data dictionary describing individual fields. Written certification by the contractor of 98% transfer accuracy will be required. A description of quality control procedures and results will be included in required metadata. Metadata will be FGDC compliant and provided as a digital product that can be imported directly into Arc/Info 8.0 or later metadata tools.

Another source of error could be incorrect field interpretation or identification. The Sierra Nevada Network will use the following strategy for validating data. All contracts will include minimum identification accuracy standards. The identification standard will be 90% for plants and 98% for vertebrates. To assure compliance with this standard, the NPS will employ a contractor or internal NPS staff to validate a sample of voucher specimens for accuracy. In addition to reviewing identification accuracy, NPS staff or a contractor will review all or parts of databases to test for logic and consistency errors. Based on review of parts or entire selected databases, further actions may or may not be warranted. Any follow-up activities will be based on verification findings and the specific nature of errors.

Each project scope of work will establish minimum requirements regarding how much of the fieldwork must be done by the principal investigator. The Sierra Nevada Network will require submission of resumes from all individuals involved in the project. Any proposed substitution of personnel will require prior approval by the Sierra Nevada I&M Network Coordinator/Data Manager.

5.5.1 New Voucher Specimens and Curation

Herbarium voucher specimens will be collected for all new vascular plant species encountered during the inventory in accordance with the collections polices outlined in NPS Management Policies, Museum Objects and Library Materials (5:9-11), Security and Protective Measures (5:13-12), Preservation of Data and Collections and Protection of Research Potential (5:3-4), and NPS-77, the Natural Resource Management Guidelines. Additionally Voucher specimens will be cataloged in ANCS+ and NPSpecies and placed in the parks' respective herbariums. See Voucher Policy, Section 4.5 for additional details.

The Museum Technician at SEKI has responsibility for ANCS+ entry for both SEKI and DEPO. At YOSE, the curatorial staff at the Yosemite Museum has responsibility for ANCS+ entry.

5.6 Making Data Accessible

Providing simplified access to data and derived products is an obvious need that continues to grow in importance. NRBib, with access to bibliographic information and abstracts, is currently accessible through a client's Internet browser. Data entry via an Internet portal and migration of the database from Lotus Notes to Oracle will occur in the near future. NPSpecies is being ported from MS Access to an Oracle database and will be accessible via an Internet browser for both queries and online updating in 2001. During FY 2000, the Dataset Catalogue database structure is being revised, a new MS Access application being developed, and the Internet-based system will be revised and migrated from Lotus Notes to an Oracle system. All of these systems will provide clients access through their Internet browsers and will give staff access to real-time best available information. Local Sierra Nevada Network training and orientation to these information systems will be completed in 2001.

At the local Network level, several initiatives are simplifying access to information. The ArcView Theme Manager will be implemented at both SEKI and YOSE. The software's capability to create themelists that remove an ArcView user's need to know where digital data are located and provide access to related metadata and hotlinks is an efficient method for simplifying access and retrieval of geospatial-related information. SEKI and YOSE will deploy ArcView Theme Manager in 2000-2001.

At SEKI, a new file structure hierarchy has been agreed upon and existing data transfer to populate the new file structure is nearly complete. A similar effort using a comparable file structure will be started at YOSE and DEPO in 2001. Having a standardized file hierarchy with established digital locations for information will improve our ability to archive, retrieve, and manage important data.

Synthesis is an information portal for providing easy access to documents, Internet addresses, databases, images, and GIS projects. SEKI and DEPO are completing a limited deployment of Synthesis in 2000-2001. Until Synthesis is moved from Beta version to fully functioning software, deployment of Synthesis will focus only on accessing key data and documents.

Providing public access to key natural resource information and data through park web pages and the Internet is crucial to educating the public about resource stewardship and protection. In 2001, the Web pages and natural resource profiles for all three parks will be further developed to provide better and expanded access to natural resource data and information. The Sierra Nevada Network I&M Coordinator/Data Manager will have oversight and responsibility for this task. We obligated $2500 to a contractor in FY2000 to complete natural resource web development for DEPO and SEKI. So far the contractor has designed a series of natural resource web concept pages that will be preceded by the new standardized natural resource profile web page currently under development. In 2001, we will obligate $2500 for YOSE to complete natural resources web page development consistent with the new national standards.

Table 3. Data Management Budget for Natural Resource Inventory

Activities	Responsibility	FY2000	FY 2001 Expenses	FY 2002 Expenses	FY 2003 Expenses	FY 2004 Expenses	Total
Oversee and supervise network data management	Network Coordinator/Data Manager GS-11 term	**$0**	**$12,500** ½ FTE **for 5 months**	**$31,500** ½ FTE for 12 months	**$31,500** 1/2 FTE for 12 months	Unfunded I&M Network Coordinator/ Data Management Position	**$75,500**
Support for data management	2 GS-07 seasonal data specialists	**$0**	$0	$20,000 for 8 pay periods per position	$21,000 for 8 pay periods per position		**$41,000**
NPSpecies	ECO Intern (Helmy) supv. by Graber	**$13,800** Salary, Travel, and ECO overhead					**$13,800**
Data Access and Utilization	ECO Intern (Gifford) supv. by Lineback	**$15,842** Salary, Travel, and ECO overhead					**$15,842**
NPSpecies & NRBib	ECO Interns (2X) supv. by I&M Coord./Data Man. and Lineback/Meyer	**$25,858** (Salary and Travel 12 Weeks) – 2 positions	Funding from FY2000. Interns wrk winter 2001				**$25,858**
Web Page Development SEKI/DEPO/ YOSE	Network Coordinator/Data Manager	**$2500** Contract Work to be completed for DEPO and SEKI during FY2001	**$2500** YOSE staff to complete web page development	Web Maintenance	Web Maintenance	Web Maintenance	**$5,000**
NPSpecies	Network Coordinator/Data Manager	Start	Finish	Database maintenance	Database maintenance	Database maintenance	
Dataset Catalogue/FGDC Compliant Metadata	Network Coordinator/Data Manager		Start	Continue	Finish	Data maintenance	
I&M Database Template	Network Coordinator/Data Manger			Start	Data maintenance	Data maintenance	
Develop Data Collection and Handling Standards/Protocol	Network Coordinator/Data Manager		Complete	Modify as Needed	Modify as Needed	Modify as Needed	
Synthesis	Network Coordinator/Data Manager	Beta-Testing and Test Deployment	Start (SEKI,DEPO)	YOSE - Modify SEKI/DEPO as Needed	Update as Needed	Update as Needed	
ArcView Theme Manager	Network Coordinator/Data Manager	Beta-Testing and Test Deployment	Start	Update as Needed	Update as Needed	Update as Needed	
Standardized File Structure	Network Coordinator/Data Manager	Develop Standards	Start	Update as Needed	Update as Needed	Update as Needed	
NRBib	Network Coordinator/Data Manager	Updates to YOSE and SEKI Completed	ECO Interns Work Winter 2001 (See above)	Update as Needed	Update as Needed	Update as Needed	
Total		**$58,000**	**$15,000**	**$51,500**	**$52,500**	**$0**	**$177,000**

SECTION 6 - PROJECT DESCRIPTIONS

List of Projects

Vascular Plant Projects

1. Special Status Vascular Plant Surveys in SEKI, YOSE and DEPO
2. Vascular Plant Inventory of Devils Postpile National Monument
3. Distribution and Abundance of Exotic Plants in Areas of Natural Disturbance in Yosemite National Park.
4. Vascular Plant Species List Documentation for the Sierra Nevada Network

Vertebrate Animal Projects

5. Inventory of Bat Species in Sequoia and Kings Canyon National Parks and Devils Postpile National Monument
6. Terrestrial and Aquatic Vertebrate Survey

6.1 Special Status Vascular Plant Surveys in SEKI, YOSE and DEPO

Background

Comprehensive surveys are needed to identify, locate and document the distribution of special status vascular plant taxa within the Sierra Nevada Network parks. Special status taxa include those that have state or federal status, are recognized by the California Native Plant Society as rare or endangered, are at the limit of their natural range, occur only in small or isolated populations, or are restricted to unusual habitats. Such inventories will contribute to a better understanding of the processes that maintain and preserve park ecosystems, allow managers to anticipate impacts from development and/or visitor use, and to monitor population trends in species identified as indicators of environmental change. The tasks identified in this project statement are intended to address this basic inventory need within the Sierra Nevada Network.

Objectives

1. Develop a list of special status plant species both known to and likely to occur within each of the Sierra Nevada Network parks.
2. Prepare a summary of inventory efforts targeting special status plant species that have been completed to date within each of the Sierra Nevada Network parks, including an assessment of geographic and ecological completeness.
3. Develop a survey strategy for detecting occurrences of special status species within each of the Sierra Nevada Network parks.
4. Conduct directed field surveys for high priority special status plant species within the Sierra Nevada Network parks.

Stratification and Sampling Strategy

Sources for the list of special status plant species will include but not be limited to The Jepson Manual: Higher Plants of California (Hickman 1993), inventory results from adjacent national forest lands, the

California Natural Diversity Database, and the most recent edition of the California Native Plant Society *Inventory of Rare and Endangered Vascular Plants of California.*

The overall sampling strategy developed during phase one of this project will stratify the network parks based on habitat types and an assessment of geographic and ecological completeness of previous search efforts. As current funding levels will not support exhaustive searches for all vascular plant species of special concern within the network parks, priority will be given to those species with federal listing status, or that are threatened by proposed or existing management activities. Next in priority will be species with state listing status, CNPS listing status and species at the limit of their range. Following development of this priority list, species-specific strategies will be based on the use of predictive models using GIS tools and species habitat preferences.

Field surveys will emphasize detecting new populations of species known to occur within each park as well as occurrences of taxa previously undetected yet likely to occur. Locations will be documented according to standard protocols, including the use of global positioning system technology to determine precise locations. Each site will be characterized by recording environmental parameters such as slope, aspect, elevation, substrate, a description of the surrounding plant community using the National Vegetation Classification Standard at the alliance or association level and associated species.

Implementation Plan

Phase 1. The development of a list of special status plant species both known to and expected to occur within the network parks, an assessment of the geographic and ecological completeness of previous search efforts, and the development of an overall survey and sampling strategy for detecting and determining the distribution and abundance of high priority species (Tasks 1-3), have been contracted out to the environmental consulting firm of Jones and Stokes in Sacramento, California. NPS plant ecologists at YOSE and SEKI, and the USGS plant ecologist at YOSE are coordinating this contract.

Phase 2. Field surveys to detect and document the distribution and abundance of high priority special status species will be carried out under contract following completion of phase 1. The contractor will be responsible for all deliverables, including field survey data, reports, spatial data products, and fully populated and documented databases.

Database Design

Access databases. MS Access relational databases will be created to store the list of known and potential species and occurrence records for each special status species known to occur within each network park. Required fields will include the scientific name, justification and source of information leading to inclusion on the list, life history attributes, known and expected distributions, and habitat preferences. UTM coordinates of all known locations will be recorded, along with the source of the location data (maps, GPS) and the associated error recorded in meters.

Project findings will be updated in the service wide biological databases including NPSpecies, Natural Resources Bibliography, and the Dataset Catalog. Metadata will be created in accordance with FGDC standards. Vouchers collected during the course of field surveys will be documented in ANCS+.

GIS data. Spatial maps will be created in ArcView format to document known locations of special status plant species, extent of previous search efforts, and the potential distribution of high priority species based on habitat models. Spatial data products will be compatible with the ArcView GIS Theme Manager and will have FGDC-compliant metadata.

Analysis

Ecological and geographic completeness of previous survey efforts will be assessed using ArcInfo GIS tools. Predictive habitat models will be created within the ArcInfo GIS environment.

Deliverables

1. A comprehensive list of all special status vascular plant species both known to occur and likely to occur within each of the Sierra Nevada Network parks.
2. A written report documenting the methods used in compiling the species list, the database design, and the contents of each field.
3. Distribution maps in ArcView format documenting known occurrences of special status plant species within each of the network parks with attribute data specifying date of last survey and abundance information.
4. A summary of previous inventory efforts targeting special status plant species, including an assessment of geographic and ecologic completeness.
5. A fully documented strategy for conducting surveys to document the distribution and abundance of high priority special status plant species within each of the network parks, including predictive habitat models for selected species.

Budget

	FY00	FY01	FY02	FY03	FY04
Phase 1: Jones and Stokes Contract	20,000				
Phase 2: Field surveys, YOSE			25,500		
Field surveys, SEKI				25,000	

6.2 Vascular Plant Inventory of Devils Postpile National Monument

Background

Directed surveys for graminoid, non-native, and special status plant taxa are needed to bring our knowledge of the Devils Postpile flora up to the 90% benchmark. This project will build upon the surveys of Medeiros and Morey (see section 2.1, this document) by focusing on groups of taxa and habitats under sampled by previous efforts. Although small in size (318 hectares, or 796 acres), the Postpile contains a number of unique habitats and environments, many of which are more closely allied with the Great Basin floristic province than those of Sequoia, Kings Canyon or Yosemite. It also contains a relatively high density of development (e.g. campgrounds, roads and trails) relative to its total area, which could contribute to an increased susceptibility to invasion by non-native taxa. The small size of the monument allows for a sampling intensity usually unaffordable in larger areas. Through a combination of directed searches for

underrepresented groups, the establishment of vegetation plots within representative types, and randomly placed inventory plots we will be able to complete a thorough inventory of the vascular plants of DEPO that also includes measures of distribution and abundance of much of the flora. This work will be accomplished most efficiently through having one botanical team carry out the vascular plant inventory, special status plant surveys and exotic plant surveys, while SEKI vegetation mapping crews will provide vegetation sampling support.

Objectives

1. Develop an updated, vouchered list of the vascular plants of Devils Postpile National Monument that represents at least 90% of the total vascular plant flora.
2. Document the distribution and abundance of the vascular plants of DEPO through the establishment of a network of standardized vegetation plots.
3. Document species distribution and abundance of plant species of special concern (i.e. rare plants) or other plant species of management interest (exotic plants).

Stratification and Sampling Strategy

Objective 1: Initial field surveys will focus on the detection of graminoid species (members of the Cyperaceae, Juncaceae, and Poaceae), which have been overlooked during previous botanical surveys in DEPO. Directed surveys will also be conducted within species-rich environments, including riparian corridors and meadows. Locations of plant species will be documented according to standard protocols, including the use of global positioning technology to determine precise locations. Each site will be characterized by recording environmental parameters such as slope, aspect, elevation, substrate, description of the surrounding plant community using the National Vegetation Classification Standard at the alliance or association level and associated species.

Objective 2: Recently acquired aerial photographs at the 1:15840 scale, in conjunction with available Digital Elevation Models (DEMs), will be delineated by photo interpreters as part of the Yosemite vegetation mapping program. These photographs will be used to delineate broad habitat types present within the Monument at the alliance level, which will form the basis for the randomized establishment of standardized vegetation plots within representative homogeneous vegetation types. These plots will be established according to methodologies employed by the vegetation mapping projects currently underway in the Sierra Nevada Network parks, with field assistance provided by the SEKI vegetation sampling crew. In addition, plots will be randomly established on UTM grid intersections without regard to homogeneity of vegetation. Plot size and shape will be determined according to physiognomy, following guidelines developed for the national vegetation mapping program by The Nature Conservancy (Anderson et al. 1998, Grossman et al. 1998). This network of plots will serve to both characterize the vegetation present within DEPO and to increase the detection of vascular plant species occurring there.

Objective 3: A list of special status plant species, including those that are rare or endangered, at the limit of their natural range, or occur only in small or isolated populations is being developed under separate contract (see section 6.1, this document). Directed surveys targeting those species listed for the Postpile will be carried out in key habitats identified on aerial photos and through ground reconnaissance. Locations of special status plant species will be documented according to standard protocols, including the use of global positioning technology to determine precise locations. Each site will be characterized by recording environmental parameters such as slope, aspect, elevation, substrate, description of the surrounding plant community using the National Vegetation Classification Standard at the alliance or association level and associated species. Directed searches for exotic species, in addition to the survey work described above, will be carried out in high priority environments including but not limited to developed areas, areas undergoing repeated natural disturbance, road and trail corridors, and riparian habitats. Abundance of

exotic species will be recorded through estimates of density and aerial extent for each documented population.

Implementation Plan

The SEKI Science and Natural Resources Management plant ecologist, who will supervise data collection and be responsible for all final reports and deliverables, will coordinate this project. One seasonal employee and SCA intern will carry out fieldwork over the course of a single field season. The field team will conduct directed searches for underrepresented groups, establish vegetation plots as described above, and carry out surveys in species rich environments. Directed searches will be augmented by the establishment of at least three replicate vegetation plots per recognized alliance as part of the Sequoia and Kings Canyon vegetation mapping efforts during 2001, which will increase overall search efforts and provide distribution and abundance estimates for dominant species. DEPO will provide housing and in-park transportation for field personnel as needed. The SEKI plant ecology program will provide field and laboratory equipment. Should a need for follow up surveys be indicated in subsequent years, site visits will be made by SEKI and YOSE/BRD plant ecologists.

Database Design

Access Databases. MS Access relational databases will be created to store the vascular plant lists and all confirmed occurrences. These will be patterned after the format currently being used for the SEKI vascular plant list, which includes the family, Latin trinomial, authority, common name, endemism, life form, and location of voucher specimens for each taxa. Occurrence records will include UTM coordinates, date of collection, and collector or source of data, and will be related to a database of site data collected during the establishment of vegetation plots. All databases will be documented according to standards consistent with established guidelines. Vegetation plot data will be stored in the NPS plotdata database system currently being used by the National Vegetation Mapping Program.

Project findings will be updated in the service wide biological databases including NPSpecies, Natural Resources Bibliography, and the Dataset Catalog. Metadata will be created in accordance with FGDC standards. Voucher information will be entered into ANCS+. These tasks will be accomplished by the field botanist under the guidance of the network coordinator/data manager.

GIS data. Spatial maps will be created to document known locations of all special status and exotic plant species. UTM coordinates of all documented vascular plant locations (e.g. each occurrence of special status and non-native taxa, and each vegetation plot) will be stored within the relational databases to support the creation of distribution maps of individual species as needed. Spatial data products will be compatible with the ArcView GIS Theme Manager and will have FGDC-compliant metadata.

Analysis

Vegetation plot data will be classified using standard multivariate approaches, including but not limited to the use of two-way indicator species analysis and cluster analysis. These data will be incorporated with the classification efforts currently underway as part of the vegetation mapping programs in YOSE and SEKI.

Distribution maps documenting locations of exotic species and special status plant species will be created using ArcInfo GIS tools.

Deliverables

1. A comprehensive list of all vascular plant species known to occur within Devils Postpile National Monument.
2. A written report documenting the methods used in compiling the species list, the database design, in MS Access format, and the contents of each field.
3. Distribution maps in ArcView format documenting known occurrences of special status plant species within the Postpile.
4. Distribution maps in ArcView format documenting known occurrences of exotic plant species within the Postpile.
5. Voucher specimens for each species encountered during the course of survey work will be deposited in the NPS herbarium at Sequoia and Kings Canyon as well as the Jepson herbarium at the University of California at Berkeley, with the exception of those species deemed too rare to support collection.
6. Geo-referenced digital photographs of special status vascular plant species within the Postpile.

Budget	**2001**	
Salary		
GS-7 term (10 pp)	13,400	
SCA intern	3,000	
Travel	900	
Supplies/materials	2,000	
Subtotal		19,300
Data management (~30%)	5,700	
Total		***$25,000***

6.3 Distribution and abundance of exotic plants in areas of natural disturbance in Yosemite National Park

Background

The threat to natural ecosystem function posed by invasive exotic plants is widely recognized by natural area managers (Randall 1996). Disturbance may enhance the probability of non-native plant establishment in native plant communities (Rejmanek 1989, Hobbs 1991) as long as exotic plant propagules are present (Crawley 1987). Therefore, non-native plants are most likely to establish in areas that have both a source of exotic seeds and which undergo repeated disturbance. In natural systems, river corridors and riparian areas are especially vulnerable (Macdonald et al. 1989; DeFerrari and Naiman 1994, and others) as they are subject to regular disturbance, the agent of disturbance is also an agent of propagule transport, and moisture is readily available (Pyšek and Prach 1994). Riparian zones may also act as havens, corridors, and sources of exotic plant invasions (Stohlgren et al. 1998).

Burned areas are vulnerable to exotic invasion as well because competition from established plants may be reduced after fire (Tyler and D'Antonio 1995), fire can dramatically increase the amount of bare ground available for germination and establishment (Boyd et al. 1993) and fire suppression activities may serve to transport propagules as well as disturb the soil surface. Fire can serve to maintain or increase the native

species component in some plant communities (DiTomaso et al. 1999, Lunt and Morgan 1999); it can modify the species composition and subsequent fire regime in others (Busch 1995, Milberg and Lamont 1995, Brooks 1999).

Exotic plant surveys conducted in 1998 and 1999 in Yosemite National Park focused primarily on anthropogenically disturbed areas. These areas included campgrounds, picnic areas, developments, corrals, roads and trails. Survey results indicate 130 exotic species occur in these sites alone. Four are on the "most invasive" list of the California Exotic Pest Plant Council (1996), 11 on CalEPPC's "lesser invasives" list and one on their "red alert" list. The vast majority are at lower elevations, but exotics were recorded at some of the highest elevations surveyed.

Although often more removed from direct human influence, burned areas and water courses represent areas of disturbance which are also vulnerable to invasion. Non-native plants may gain unobserved footholds in these natural areas which, if undetected, may lead to more permanent establishment and spread. Management of wildland fires is typically limited to monitoring and/or suppression while the fire is active. The fire effects monitoring program involves measuring species composition before and after prescribed burns; however, park personnel rarely have the opportunity to measure species compositional changes resulting from wildfires. Some data are available for prescribed fire areas, but surveys are needed in lightning-ignited burns to assess the extent of exotic plant establishment and the degree to which monitoring or control is needed. This project will expand the existing inventory of exotic plant species into these more remote but ecologically vulnerable sites.

These data will serve as an initial baseline against which changes in distribution and abundance of selected species can be measured. Monitoring programs are expensive, and this study will provide the data needed to prioritize subsequent monitoring of individual sites and species. Control programs are also costly, and it is an unfortunate reality that not all introduced species can be eradicated. Thus it is important to have a basis for selecting those species and areas that will receive limited control funds and to identify where changes are occurring that may necessitate action.

With the funding level available for the network and the priorities set by the network, there is sufficient support only for the survey design phase. However, there is a very high likelihood of obtaining funding from other sources to support the field survey and data analysis phases.

Objectives

1. Design inventory methods for surveying lightning-ignited burns and riparian areas for exotic plant species.
2. Document the occurrence of non-native plants in areas burned during lightning and prescribed fires.
3. Document the distribution and abundance of non-native plant species occurring in riparian areas.
4. Map surveyed areas and distribution of non-native species recorded.
5. Create spatial data in ArcView format to represent distribution of exotic plant species in disturbed areas.
6. Create Access database to store survey data

Stratification and Sampling Strategy

Spatial data on fire history in Yosemite is available for the last 70 years for lightning fires and for the last 30 years for prescribed fires. Depending on the results and recommendations of the survey design contract, burned-area sampling may be stratified by decade and categorized according to ignition source. Exotic plant populations are likely to be extremely patchy. A random component will be incorporated into the sampling approach, while, at the same time, exhaustive surveys may need to be implemented to capture the

presence of exotic species. The resulting data may lend themselves to analyses at different spatial scales to take advantage of both exhaustive and intensive approaches.

Hydrography data are available on the GIS at Yosemite. Depending on the results and recommendations of the survey design contract, riparian-area sampling may be stratified by stream order and distance from human areas and travel routes, including roads and trails.

Implementation Plan

Proposals will be solicited from qualified individuals to do background research and to design a scientifically credible survey for exotic plants in the burned and riparian areas of Yosemite National Park. Authors of the successful proposal will be supplied with the park's fire history, hydrography and other data in GIS format and given access to available information on prescribed and wildland fire extent, intensity, severity and duration. For the most part, intensity and severity information is available for only about the last 10 years.

Database Design

Access Databases. Access databases will be created to store data on non-native plant species occurrence by location. Project results will be added to the NPS Inventory and Monitoring databases, including NPSpecies, ANCS+, Natural Resources Bibliography, and the Dataset Catalog. Metadata will be created in accordance with FGDC standards.

GIS data. Spatial data will be created to document locations of all exotic plant species recorded during surveys together with attribute data. UTM coordinates of survey locations and locations of exotic plant populations will be stored in spatial databases for a record of species distributions.

Analysis

A spatial database will be created from survey information on areas surveyed, age and type of fire, stream order and location and exotic plant populations encountered. Species richness and evenness may be compared between lightning fires and prescribed fires for comparable areas and among streams at varying distances from human development.

Deliverables

1. A report documenting the study area, methods, database design, analysis, results and discussion.
2. Spatial data created in the design of survey methods that will assist in locating survey areas.

Deliverables for survey and analysis phases

1. Distribution maps, in ArcView format, documenting exotic plant populations recorded during surveys in Yosemite.
2. Voucher specimens for non-native species collected during surveys prepared for cataloging and accessioning into the Yosemite Herbarium.
3. Data on all exotic plant species recorded during surveys in a format compatible with NPSpecies and information on collected specimens for inclusion in ANCS+. Both types of information will be stored in MS Access format.

Budget

2001 (**funded**)	
Survey Design Contract	$11,000
2002 (**unfunded**)	
Salary	
GS-7 temp (8 pp)	9,830
GS-7 temp (8 pp)	9,830
GS- 5 temp (6 pp)	5,952
GS- 5 temp (6 pp)	5,952
Travel	1,000
Transportation (GSA)	5,090
Supplies/materials	2,345
Subtotal	40,000
Data management (25%)	10,000
Total	$50,000

6.4 Inventory of Bat Species in Sequoia and Kings Canyon National Parks and Devils Postpile National Monument

Background

A review of existing literature (Allen 1919, Constantine 1998, Dial et al. 1979, Grinnell 1913, 1916 &1918, Hall 1981, Lengas and Bumpus 1992 & 1993, Pierson and Heady 1996, Pierson and Rainey 1998b) and museum records for the Sierra Nevada reveals that there are very few bat records for the portions of this mountain range that include Sequoia and Kings Canyon National Parks and Devils Postpile National Monument. Joseph Grinnell's extensive work in the 1920's focused on transects through Yosemite and Lassen National Parks (Grinnell and Storer 1924, Grinnell et al. 1930), and did not include the southern Sierra Nevada. Since these early faunal surveys did not have the current survey tools (e.g., mist nets, bat detectors, night vision devices) available to them, and were largely based on shooting at dusk with a shotgun, the number of bats collected was relatively limited. On the Yosemite transect, for example, only nine species were collected (Grinnell and Storer 1924).

Based on what is known regarding the distribution and habitat of California's twenty-five species, seventeen would be expected to occur in Sequoia and Kings Canyon National Parks, and between thirteen and seventeen in Devils Postpile National Monument. Recent work in Yosemite National Park examining the seasonal distribution of bat species over an elevational gradient has documented 17 species as occurring in the Park (Pierson and Rainey 1993,1995, 1996a, Pierson et al. 2000b), and shown that the species assemblage (particularly where the breeding females are found) is strongly influenced by altitude. In the vicinity of Yosemite National Park, the zone of highest diversity, which includes both those species confined to lower altitudes and those found primarily at higher altitudes, is at ca. 1,000-2,000 meters (Pierson et al. 2000b).

Latitude also affects distribution, leading to the expectation that there would be differences between Yosemite National Park and Sequoia-Kings Canyon. For example, a study conducted in the Giant Forest area found the pallid bat, *Antrozous pallidus*, to be one of the species most commonly associated with the giant sequoias (*Sequoia giganteum*). Yet, a parallel study now underway in Yosemite National Park suggests that pallid bats are relatively rare at a comparable altitude in the Mariposa Grove.

The goal of this study would be to conduct an inventory of the bat species in Sequoia and Kings Canyon National Parks and Devils Postpile National Monument. Since the species assemblage would be expected to change with altitude and latitude, sampling would be conducted in five generally westward flowing river drainages (the Middle and South Forks of the Kings River, the Middle and South Forks of the Kaweah River, and the Kern River), selecting sampling sites at approximately 600 m intervals, between 600 and 3000 m (recognizing that there are relatively few sites within park boundaries at elevations as low as 600 m).

Since sampling for bats generally involves locating animals in their foraging habitat, and foraging behavior varies considerably among species (e.g., some feed over open water, others in association with riparian vegetation, others over open meadows), it is necessary to survey a variety of micro-habitats within any general locality. Specifically, we would sample for bats over several classes of open water (lakes/ponds, rivers, and tributary streams), over meadows, along meadow edges, at the base of cliffs, and at the rock/forest edge.

Also, sampling methods vary considerably in their effectiveness among species (Kalko et al. 1996, Pierson and Rainey 1996b, Simmons and Voss 1998). To obtain the most complete characterization of the bat community it will be necessary to use both acoustic and capture methods. Acoustic methods offer the most effective way for assessing overall levels of bat activity at a sampling site, and for detecting the presence of certain species that are rarely captured in nets and have distinctive echolocation calls (e.g., red bats, *Lasiurus blossevillii* [Pierson et al. 2000a], mastiff bats, *Eumops perotis* [Pierson and Rainey 1998a], and spotted bats, *Euderma maculatum* [Pierson and Rainey 1998b]). Capture methods, while labor intensive, offer the only opportunity to obtain demographic data (particularly important for locating breeding females) critical to proper management, and allow positive species identification for those species that are difficult to distinguish acoustically (e.g., big brown bats, *Eptesicus fuscus* versus silver-haired bats, *Lasionycteris noctivagans* [Betts 1998]; the three *Myotis* species that echolocate at 40 kHz, *Myotis ciliolabrum*, *Myotis lucifugus*, and *Myotis volans*).

We would sample similar foraging habitat types at a series of sampling sites located at approximately 600 m intervals along an elevational gradient in selected drainages. We would employ multiple acoustic detectors and sample several net sites per night, but because this would be essentially a regional reconnaissance, we would sample each site only once.

Proposed schedule of work (to be conducted in 2003 and 2004)

Reconnaissance -- Selection of sites available by road (E.D. Pierson only) (5 days)

Kings Canyon National Park

Middle Fork of Kings River (10 days) -- Tehipite Valley to Bishop Pass

South Fork of the Kings River (10 days) -- Cedar Grove to Onion Valley

Sequoia National Park

Middle Fork of the Kaweah (10 days) -- Ash Mountain to Kaweah Gap to Mineral King via Big Arroyo

South Fork of the Kaweah (4 days) -- Mineral King to South Fork Ranger Station

Kern River (6 days) -- Tyndall Creek Ranger Station to Kern Canyon Ranger Station

Devils Postpile National Monument

Reconnaissance survey (2 days)
Mid-summer survey (4 days)
Fall survey (2 days)

Staff

Elizabeth D. Pierson, Ph.D. (University of California, Berkeley, 1986). Twenty-five years of field/research experience with bats, with a focus on California since 1979. Research experience with a number of special concern species. Consulting biologist since 1987. Extensive experience with all the field techniques used for bat assessment. Member of the Executive Committee of the Western Bat Working Group; co-author of bat species accounts for new edition of CDFG Mammal Species of Special Concern. Extensive back country experience.

William E. Rainey, Ph.D. (University of California, Berkeley, 1984). Over twenty years of experience with community ecology, and 19 years experience with bats. Research experience with a number of special concern species. Extensive experience with all the field techniques used for bat assessment. Particular interest in association of bat communities with river systems. Co-author of bat species accounts for new edition of CDFG Mammal Species of Special Concern. Extensive back country experience.

Chris Corben, B.S. Biologist. A leading authority on bat acoustic survey techniques. Designed acoustic hardware and software (Anabat, Titley Electronics, Australia) now used worldwide for bat acoustic surveys. Extensive experience with acoustic identification of California species.

Mary Ellen Colberg, B.S. Biologist. Ten years of field experience with bats. Competent with all field techniques. Extensive back country experience.

Deliverables

1. A list of bat species detected in Sequoia and Kings Canyon National Parks and Devils Postpile National Monument
2. A map of locations sampled and where bats were detected in Sequoia and Kings Canyon National Parks and Devils Postpile National Monument
3. A database containing all locations where bats were detected
4. Annual progress reports
5. A final report describing the methods used, locations sampled, and results of sampling for bats. The report will include an analysis of habitats used by bats and descriptions of preferred habitats for each bat species detected.

Budget

Personnel	
E.D. Pierson	$13,250
3 Field Associates	$24,000
Data Analysis/Report	
25 days	$7,500
Administration	
8 days	$2,400
Travel Costs	
Per Diem	$3,700
Mileage	$3,150
Equipment/Supplies	$5,000
Logistical Support	
Misc.	$6,000
Total	$65,000

6.5 Terrestrial and Aquatic Vertebrate Survey

Background

Collecting trips by the National Museum, California Academy of Sciences, and especially the Museum of Vertebrate Zoology contributed significantly to our early knowledge of the vertebrate fauna inhabiting Sequoia, Kings Canyon, and Yosemite National Parks. Voucher specimens acquired during these trips constitute an invaluable record of historic species occurrence. Unfortunately, these historic data are of questionable value in describing the current status of vertebrate fauna because of predator control efforts, substantial numbers of road kills, trapping and poaching along the park boundaries, as well as, habitat changes due to fire suppression, vegetation succession, and in the case of Yosemite, extensive logging of lower and mid-elevation forests. In addition, imprecise location information on specimen tags or in field notes limits the use of these data for assessing current distribution or creating models to predict species occurrence. For these reasons, we used the voucher specimens as a starting point when preparing the list of species predicted to occur. We subsequently used data from the park wildlife observation databases to augment the voucher based species list. Finally, we used species range maps and the professional expertise of park wildlife biologists to complete the list of species predicted to occur in the Sierra Nevada Network parks.

A preliminary comparison of predicted species occurrence with actual occurrence (based on wildlife observations recorded within the past 20 years and the professional expertise of park wildlife biologists) suggested that Sequoia, Kings Canyon, and Yosemite exceeded the 90% benchmark for knowledge about the status of vertebrate species inhabiting the parks. A closer examination of these results, however, revealed that our knowledge varied considerably by taxa (Table 4). We found that status information for birds generally exceeded 90% while information on amphibians, reptiles, and mammals fell below that level. We attributed this disparity to differences in detectability; birds are typically more conspicuous and easily identified than other taxa. We concluded that the abundance of status information for birds, coupled with the high number of bird species masked the lower percentages of documented occurrence for other vertebrate groups. Further investigation also revealed within taxa differences in status information. Charismatic megafauna, such as bears, were well represented in the faunal databases and multiple records also existed for species that are widely recognized (deer, raccoons, rattlesnakes). Cryptic, nocturnal, or secretive species were generally under represented.

Based on the results of our analysis, we compiled a list of priority species for which we lack current status information (Table 5). These are species on the list of vertebrates predicted to occur that have not been documented by a credible wildlife observation record or sighting within the past twenty years. A separate list was compiled for each network park.

The most significant gaps in knowledge identified for Sequoia and Kings Canyon National Parks occur within the caudate amphibians, mid-sized carnivores, lagomorphs, and rodents. The list of species targeted for presence or absence survey at Sequoia and Kings Canyon National Parks was developed from a careful review of the observation database supplemented by staff experience. The list includes species by three criteria: 1) They have never been reported but are likely to reside either permanently or seasonally within the park based on information from range maps and other published sources; 2) They have been reported but there is reasonable suspicion about the accuracy of the identification; or 3) There are no records from within the last 20 years, and there are concerns that they may have been lost from the park fauna. Priority fish and bat species were omitted from this list because the fish survey work will be done in-house under a recently funded aquatic ecology program, and bats will be inventoried by an independent contractor, Dixie Pierson (see section 6.4).

The list of priority species in Yosemite was generated by reviewing the park's species list and eliminating from consideration, species or groups that have been recently studied (caudate amphibians, ranid amphibians, forest carnivores, bats, birds), those that are observed regularly (eg. California newt, Pacific tree frog, rattlesnake, black bear, gray squirrel, mule deer), and easily identifiable species with recent (< 20 years) observation records in the park's faunal database (eg. mountain king snake, rubber boa, ringtail, bobcat). Through this process, we identified gaps in information for several species of small mammals, most notably, insectivores, chipmunks, and microtine and cricetid rodents.

The dearth of previous work in Devils Postpile will require a full survey of vertebrate fauna within the monument.

Table 4. Estimate of vertebrate knowledge in Sierra Nevada Network parks.

	Sequoia NP	Kings Canyon NP	Yosemite NP	Devil's Postpile NM
Fish				
Number of species reported/ % of potential present	12/67%	5/71%	12/100%	5/100%
Number reported since 1979/ % of potential present	12/67%	3/40%		5/100%
Number of species potentially present	18	7	12	5
Amphibians				
Number of species reported/ % of potential present	11/79%	8/80%	11/100%	1
Number reported since 1979/ % of potential present	9/64%	7/70%	9/82%	1
Number of species potentially present	14	10	11	To be determined
Reptiles				
Number of species reported/ % of potential present	23/88%	17/81%	21/100%	3
Number reported since 1979/ % of potential present	22/85%	16/76%	17/85%	3
Number of species potentially present	26	21	21	To be determined
Birds (excluding accidentals)				
Number of species reported/ % of potential present	170/96%	152/86%	166/100%	54
Number reported since 1979/ % of potential present	169/95%	150/85%	166/100%	54
Number of species potentially present	177[a]	177[a]	166	To be determined
Mammals				
Number of species reported/ % of potential present	76/82%	64/69%	83/93%	16
Number reported since 1979/ % of potential present	69/74%	52/56%	52/58%	16
Number of species potentially present	93	93	89	To be determined

Table 5. Priority Vertebrate Species at Sequoia, Kings Canyon, and Yosemite National Parks. The "X"s mark species for which there is reason to suspect presence, but they are either unreported for the respective park, there is uncertainty about the reliability of reports, or there are no records from the last twenty years.

Binomial Name	Common Name	Sequoia NP	Kings Canyon NP	Yosemite NP
	Amphibians			
Taricha sp	Undescribed Taricha	X		
Batrachoseps relictus	Relictual Slender Salamander	X		
Batrachoseps simatus	Kern Canyon Slender Salamander	X		
Batrachoseps sp	Undescribed Batrachoseps	X	X	
Aneides lugubris	Arboreal Salamander			X
	Reptiles			
Clemmys marmorata	Western Pond Turtle		X	
Phrynosoma coronatum	Coast horned Lizard	X		
Uta stansburiana	Side-blotched Lizard	X		
Cnemidophorus tigris	Western Whiptail		X	
Eumeces skiltonianus	Western Skink	X	X	X
Scleporus occidentalis	WesternFence Lizard			X
Sceloporus graciosus	Sagebrush Lizard			X
Anniella pulchra	California Legless Lizard	X		
Diadophis punctatus	Ring-necked Snake		X	
Hypsiglena torquata	Night Snake		X	X
Contia tenuis	Sharp-tailed Snake			X
Rhinocheilus lecontei	Long-nosed Snake		X	
Thamnophis sirtalis	Common Garter Snake		X	
	Birds			
Tyto alba	Barn Owl		X	
Strix nebulosa	Great Gray Owl	X		
Tosastoma redivivum	California Thrasher		X	
Spizella atrogularis	Black-chinned Sparrow		X	
Carpodacus mexicanus	House Finch		X	
Passer domesticus	House Sparrow		X	
	Mammals			
Sorex lyellii	Mount Lyell Shrew			X
Sorex vagrans	Vagrant Shrew	X	X	X
Sorex monticola	Dusky Shrew			X
Sorex ornatus	Ornate Shrew		X	X
Sorex palustris	Water Shrew			X
Sorex trowbridgii	Trowbridge Shrew			X
Vulpes vulpes	Red Fox		X	
Mustella vison	Mink	X	X	
Taxidea taxus	Badger		X	
Tamias amoenus	Yellow-pine Chipmunk		X	X
Tamias minimus	Least Chipmunk	X	X	X
Tamias quadrimaculatus	Long-eared Chipmunk		X	X
Tamias senex	Allen's Chipmunk		X	X
Tamias merriami	Merriam’s Chipmunk			X
Tamias alpinus	Alpine Chipmunk			X
Tamias umbrinus	Uinta Chipmunk	X	X	
Chaetodipus californicus	California Pocket Mouse			X
Perognathus parvus	Great Basin Pocket Mouse			X
Onychomys leucogaster	Northern Grasshopper Mouse			X
Onychomys torridus	Southern Grasshopper Mouse	X		
Zapus princeps	Jumping mouse			X

Binomial Name	Common Name	Sequoia NP	Kings Canyon NP	Yosemite NP
Peromyscus boylii	Brush Mouse		X	X
Peromyscus maniculatus	White-footed deer mouse			X
Peromyscus californicus	California Mouse		X	X
Peromyscus truei	Pinyon Mouse		X	X
Reithrodontomys megalotis	Western Harvest Mouse		X	X
Microtus californicus	California Vole		X	
Phenacomys intermedius	Heather Vole	X	X	X
Neotoma fuscipes	Dusky-footed Woodrat			X
Erethizon dorsatum	Porcupine			X
Lepus americanus	Snowshoe Hare	X	X	X
Lepus californicus	Black-tailed Jack Rabbit		X	
Sylvilagus audubonii	Desert Cottontail	X	X	

Objectives

1. Conduct rapid assessment of the current status (presence/absence) of priority vertebrate species within Sequoia, Kings Canyon, and Yosemite National Parks using targeted searches in preferred or historic habitats.
2. Investigate the distribution and abundance of vertebrate species inhabiting Sequoia, Kings Canyon, and Yosemite National Parks using stratified random sampling (time and funding permitting).
3. Investigate the status of rare vertebrate species (Sierra Nevada red fox, wolverine, Pacific fisher, etc.) in Sequoia, Kings Canyon, and Yosemite National Parks using a combination of automated camera systems and snow track surveys by staff biologists.
4. Develop a list of predicted occurrence for vertebrate fauna inhabiting Devils Postpile National Monument using range maps and professional expertise of staff biologists in the Sierra Nevada Network parks.
5. Conduct vertebrate faunal surveys in Devils Postpile National Monument using a combination of targeted surveys in preferred habitats and stratified random sampling.

Sampling Methods

The diversity of taxa on the network priority species list will require a flexible approach to sampling. We suspect that some species, particularly the small and medium sized rodents, will be readily detected while other species, most notably caudate amphibians and snakes, will take much longer to find. Sampling for vertebrates will initially employ targeted searches to determine presence/absence for network priority species. Targeted searches will focus on historic locations and preferred habitats to maximize the efficiency and likelihood of determining species occurrence. The preferred habitat for network priority species will be determined from a search of the literature. We will subsequently map the distribution of the preferred habitats using the parks' GIS and sample in a randomly selected subset of those habitats.

The primary method of sampling for terrestrial mammals will be live trapping using pitfall traps with drift fences for insectivores and "Sherman traps" (H. B. Sherman, Tallahassee FL) to capture small and medium sized rodents. We will use motion activated cameras baited with salt blocks to detect porcupines and unbaited cameras deployed along game trails for lagomorphs and larger mustelids. Amphibians and reptiles will be detected using a combination of cover boards, pitfall traps with drift fences for lizards and small snakes, cone traps and drift fences for larger snakes, and time constrained searches in suitable habitats.

For targeted searches, pitfall traps with drift fences will be established at 30 m intervals along a 300 m long transect. Cover boards will be placed at each end of the drift fence. Paired Sherman traps will be interspersed at 10 m intervals along the same transect. Each transect will be oriented to capture the widest range of habitat variation. Although the number of transects within a particular habitat type will vary depending on the areal extent of that habitat, we envision establishing an array of three transects with their midpoints located 0.5 km apart whenever possible. This arrangement is designed to survey large areas and capture the greatest diversity of species. Time constrained searches in suitable habitat will involve looking under surface objects (logs, rocks, leaf litter) for caudate amphibians and lizards for an yet to be determined time period.

Once presence/absence has been determined for network priority species, we will expand sampling efforts to incorporate a stratified random design using vegetation as the basis for sampling site selection. The objective of this effort is to gather information on the distribution and relative abundance of other vertebrate species inhabiting the parks. Trap layout for systematic random sampling will consist of a 10 by 10 grid of paired Sherman traps spaced 10 m apart. The center of the grid will be a random distance (up to 10 m) and direction from the point identified by GPS receiver as the center of the sampling site. Trap pairs within the grid can be placed up to 2 m from the associated grid intersection to take advantage of surface features (logs, rocks, burrows) that will potentially increase trapping success. Because Sherman traps tend to under sample insectivores, we will also install 2 pit traps with drift fences at each sampling site. These will be placed at a random distance (between 100 m and 150 m) and direction from the center point of the sampling site. We will also place coverboards at ends of each drift fence.

In addition to sampling for animals, we will also collect information on vegetation cover, composition, and structure at each site. These data will be used to develop, test, and improve wildlife habitat relationship models. The basis for identifying habitats will be the vegetation classification described by the California Wildlife Habitat Relationships System (CWHR).

The project in Sequoia, Kings Canyon, and Yosemite National Parks will be supervised by the parks' wildlife biologist in SEKI and YOSE, respectively. Sampling will generally be conducted by a two person team of field technicians although we anticipate occasional participation by park staff. The sampling team will travel to, and precisely locate, sampling sites using GPS receivers. In addition to identifying each captured animal to species, they will collect basic biological data, including sex, estimated age, and physical measurements. Trapped animals will be handled in accordance with NPS policies for the care and handling of live animals. Every effort will be made to minimize trapping related mortality, however, in the event that mortalities do occur, carcasses will be preserved as voucher specimens.

The lack of basic information about the vertebrate fauna of Devils Postpile National Monument will require a complete survey for all taxonomic groups. A list of predicted species occurrence will be compiled from range maps and the professional expertise of wildlife biologists in the Sierra Nevada Network parks. This will be compared with the results of sampling. Sampling for birds will be conducted by wildlife biologists from SEKI and YOSE. A biological technician, supervised by the wildlife biologist in SEKI, will reside at DEPO and conduct stratified random sampling for terrestrial vertebrate species. Sampling protocols in DEPO will generally follow those used in the other network parks.

The period of sampling will be approximately 12 weeks from spring through early autumn with the timing of sampling at a particular location dependent on accessibility and prevailing weather conditions. The length of time spent at a particular location will vary with whether sampling is

targeted or stratified random. In general, however, sampling at any given location will extend at least 1 week and may last up to three weeks.

Database Design

Observations and habitat information will be stored in a relational database. All locations taken from GPS equipment will be recorded to the nearest meter using UTM coordinates and horizontal error will be recorded. Locations taken from maps will be recorded to the nearest hundred meters. The source of all coordinates (e.g. GPS, USGS map, curser over GIS layer, etc.) will be recorded in the database.

Access Databases

One database per vertebrate group (e.g. mammals, reptiles, etc.) per park will be used for all mammal observations. Required fields for mammals include date, time, UTM coordinates, horizontal error, source of coordinates, species, sex, age, habitat, elevation, aspect, and comments. Where mammals were handled, additional fields include total length, tail length, hind foot, ear, weight, and disposition of the specimen (e.g. released, voucher specimen, etc.). Required fields for reptiles include date, time, UTM coordinates, horizontal error, source of coordinates, species, number of individuals by age (adult, juvenile), sex, habitat, elevation, aspect, and comments. Where reptiles were handled, additional fields include total length, snout-vent length, weight, and disposition of the specimen (e.g. released, voucher specimen, etc.). Required fields for caudate amphibians include date, time, UTM coordinates, horizontal error, source of coordinates, species, number of individuals by age group, habitat, elevation, aspect, and comments. Where amphibians were handled, additional fields include total length, snout-vent length, weight, and disposition of the specimen (e.g. released, voucher specimen, etc.). Required fields for fish include date, time, UTM coordinates, horizontal error, source of coordinates, species, number of observed individuals by size group, habitat, elevation, aspect, and comments. Where fish were handled, additional fields include fork length, weight, and disposition of the specimen (e.g. released, voucher specimen, etc.).

GIS Data

A spatial map will be created for each species showing observations attributed for horizontal error and source of coordinates (e.g. GPS or map). Additionally, there will be a map showing potential range based on modeling of optimum and marginal habitat and known distribution constraints.

Analysis

The analysis will follow two directions. 1) The relationship between habitat and relative abundance (based on number of observations at a site) will be evaluated for each species. This will allow for developing models of predictive occurrence based on habitat parameters. 2) Identify areas that are especially significant. These may include areas of high diversity or areas that are especially important ecologically.

Deliverables

1. Species list by network park showing observations by habitat
2. ArcView GIS themes showing observations and predicted distributions
3. Report summarizing observed habitat requirements including photographs of the habitat and the species
4. Voucher specimens of all extant species except those that are rare

5. Material for future DNA analysis
6. Data stored in Access database
7. Updates to Servicewide biological databases
8. Annual progress reports and final report

Project Budget

Personnel

SEKI	GS-07 (12 pay periods)	$13,926
	GS-05 (12 pay periods)	11,644
YOSE	GS-07 (12 pay periods)	13,926
	GS-05 (12 Pay periods)	11,644
DEPO	GS-09 (10 pay periods)	14,702
Subtotal		**$65,842**

Transportation

SEKI/YOSE/DEPO truck (3) @ $2500 each	7,500
SEKI Helicopter/Stock Support	6,000
Subtotal	**$13,500**

Equipment

Sherman traps (500)	5,000
Remote cameras (6)	3,600
Pit Traps	800
Binoculars (4)	500
GPS (7)	1,500
Camping gear for three	2,500
compasses (3)	150
sampling equipment	500
Subtotal	**$14,550**

Supplies

film	500
maps	100
misc supplies	509
Subtotal	**$1109**

Total **$95,000**

6.6 Vascular Plant Species List Documentation for the Sierra Nevada Network

Background

Yosemite National Park. Hall and Hall (1912) reviewed collections made in 1909 and 1911 by Willis Linn Jepson and collections made in 1911 by Le Roy Abrams as well as those reviewed by K. Brandegee (1891) and J. W. Congdon (1891, 1892a, b, c). Botti (In press) reviewed collections at the California Academy of Sciences; Jepson/University of California, Berkeley; U.C. Davis; San Jose State University; and Yosemite National Park herbaria and made additional collections in the mid-1980s and into the 1990s. He compiled a list of nearly 1500 plant species, the vast majority of which are in park and/or regional herbaria. This list will be published along with identification and distribution information in early 2001 (Botti In press). However, complete information sufficient to thoroughly document the vouchers in ANCS+ and NPSpecies is not available.

The U.S. Geological Survey conducted exotic plant surveys in 1998 and 1999 (Gerlach in press), adding 50 species to the park list. There is precise location information available in the form of coordinates for the exotic plant collections made during these surveys as well as a location name, name of the collector, and collection number. However, as of this writing, these vouchers have not yet been accessioned into a collection.

Sequoia and Kings Canyon National Parks. Searches of regional herbaria for voucher specimens from Sequoia or Kings Canyon National Park were completed in the early 1980s. Information is needed on any collections made since that time documenting taxa not currently on the parks' species list.

Devils Postpile National Monument. Collections by Dr. Joseph Medeiros and Sandra Morey of Sierra College made during 1974-1980 surveys document 235 taxa for Devils Postpile National Monument in an unpublished checklist. According to local subject matter experts Jim Shevock and Dean Taylor, no other botanists are known to have collected extensively within Devils Postpile National Monument, and searches at several major California herbaria have resulted in no significant collections (Medeiros, personal communication). As a result, there is low expectation of finding collections documenting additional taxa at regional herbaria. However, DEPO will be included in searches of web postings, herbarium databases and voucher specimens in the advent that additional taxa can be verified and added to the Monument's list.

Goal

Compile a completely documented vascular plant species list for Yosemite National Park based on voucher specimens complete with all information needed for ANCS+ and NPSpecies, and capture information on vouchers that add to the evidenced taxa for Devils Postpile N. M. or Sequoia and Kings Canyon National Parks.

Objectives

1. Search databases posted on the web for collections from network units.
2. Collect information from museums and herbaria either via web-based queries or site visits
3. Enter a complete Yosemite species list into NPSpecies based on vouchers together with associated status, abundance, residency and nativity information and add to the species lists of DEPO and SEKI.
4. Enter available species evidence data from individual voucher specimens, references or highly qualified observers into NPSpecies

5. Prepare exotic plant collections from 1998 and 1999 surveys for accessioning by curatorial staff into the Yosemite herbarium.
6. Create a spatial data set from location information available on herbarium labels together with codes indicating precision of location information.

Strategy

All searches that can be done via web-based databases posted by herbaria and museums will be completed prior to site visits to those collections. Collection curators will be contacted and queried prior to site visits to maximize efficiency while at the collections. Information for vouchered specimens will be entered directly in Access databases that are compatible with NPSpecies formats. Evidence for species on the park list will be limited to voucher specimens; select, predetermined references and select, highly qualified taxonomic experts.

Implementation Plan

Web-based data on collections will be searched for Yosemite National Park vouchers (keeping in mind historic boundary changes), especially for the more distant collections. Web-based searches and correspondence (requesting electronic or hard copies that provide details on Yosemite collections) will be used in combination with site visits to regional collections, including Jepson/UC Herbaria, California Academy of Sciences, UC Davis Herbarium and San Jose State University Herbarium, to glean required information for NPSpecies.

A cursory search of 29 institutions revealed nine with information on Yosemite collections posted on the web. Some of these posted only type-specimen lists. More in-depth searches will be done to assemble voucher information, including, at a minimum, the following institutions:

Source	Web-posted Yosemite Holdings	Location
Yosemite Herbarium	4800 vouchers	Yosemite National Park
Univerisity/Jepson Herbaria	256 Tuolumne Co 256 Mariposa Co. 256 Madera Co.	U.C. Berkeley
San Jose State Herbarium	648	San Jose State University
U.C. Davis Herbarium	1 specimen	Davis, CA
Univ. Michigan Herbarium	1	Univ. Michigan
Univ. Arizona Herbarium	2	Univ. Arizona, Tucson
New York Botanical Garden	231 incl bryophytes	New York
Ownbey Herbarium	2 isotypes	Pullman, WA
Tulane Univ. Herbarium	1 type specimen	New Orleans

Arrangements will be made to access collections at regional herbaria to locate and document vouchers from Yosemite. Data from voucher labels may be entered directly into Access during site visits or entered later from hand-scanned herbarium labels or both. In addition to information needed for NPSpecies "evidence" records, location information will be stored by recording any place names and coordinates available on herbarium labels and by deriving Universal Transverse Mercator (UTM) coordinates from Topo!GPS or ArcView using collection location description. Locations based on place names alone will be assigned a precision code indicating confidence of the UTM coordinate and expressed in kilometer radius from the coordinate. Nomenclature will be converted to currently accepted names as defined in the ITIS database or corrected if rejected by the database. The Botti (In press) species list will be made available for this project.

Database Design

Access databases. Databases will be constructed in Access that mirror NPSpecies data structures for "evidence" records with the addition of UTM easting and northing coordinate fields and a comments field for additional information available from specimen labels. The coordinate fields will allow the data to be pulled into and represented in a spatial environment.

GIS data. Spatial data will be derived from the Access data tables used to store "evidence" records using the UTM easting and northing coordinates. All voucher data stored in the Access table will be made available in the ArcView GIS environment by importing the database table into ArcView and using it to create a spatial data layer for all Yosemite specimens and their data attributes. Images of hand-scanned herbarium labels will be retrievable by querying the spatial data. Spatial data from survey projects that include species abundance and location information will be stored separately by project.

Analysis

Voucher source locations stored in Access databases will be imported into ArcView to create a spatial data set to complement the textual data set. The spatial database will be designed to allow queries of the Access fields (largely NPSpecies fields plus place names and comments) and to allow viewing of hand-scanned herbarium labels.

Deliverables

1. Vascular plant species list in MSAccess format and entered into NPSpecies for all species found during voucher searches, those from references included in NRBib and observations from highly qualified observers along with associated status, abundance, residency and nativity information for each.

2. NPSpecies entries that cite "evidence" for each species on the species list in the form of vouchers found in local or regional herbaria, those from references included in NRBib and observations from highly qualified observers.

3. Spatial database containing available locations for evidenced species based on voucher collection label information, location information from references or cited locations from highly qualified observers.

Budget

2001	
Salary	
GS-7 temporary	
19PP	23,347
Travel	13,832
Supplies/materials	1,821
Total	**39,000**

SECTION 7 - PROGRAM MANAGEMENT AND ADMINISTRATION

7.1 The Sierra Nevada Network Working Group

Project Oversight and Coordination:

Dr. David Graber, Senior Science Advisor, Sequoia and Kings Canyon National Parks

Section Authors and other Contributors:

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Harold Werner, Fish and Wildlife Biologist, Sequoia and Kings Canyon National Parks

Interim Network Coordinator:

Linda Mutch, Sequoia and Kings Canyon National Park

Editor:

Jerry Mitchell, Superintendent's Office, Yosemite National Park

7.2 Network Coordination

An effective network- level inventory and monitoring program requires coordinated staffing and oversight. Recognizing that implementing a successful inventory and monitoring program creates an additional and substantial workload for network parks, the Sierra Nevada Network will hire a Network Coordinator/Data Manager to provide oversight and coordination for all aspects of the inventory phase of the program. This will be a GS-11 term position based at Sequoia and Kings Canyon National Parks. It would include the following responsibilities:

1) coordinates and provides oversight for implementation of inventory projects

2) conducts at least semi-annual meetings with network steering group to review progress, set priorities and discuss future needs

3) assures that the network meets data and reporting requirements (as defined in section 5 on data management)
   - compiles and edits annual reports for network inventory program
   - ensures that pre-existing data are appropriately documented and entered into NPSpecies and/or Dataset Catalogue for all four network parks
   - ensures that all data collected during inventory projects are processed in a timely manner and recorded in appropriate format
   - ensures that all park inventory databases are maintained and updated on an on-going basis, including updates to NPSpecies, NRBib, and Dataset Catalogue

4) assists with I&M program staff supervision and hiring

5) manages program budget and coordinates logistics

6) works with individual project managers to develop requests for proposals and detailed project statements, oversee contracts and develop cooperative agreements

7) works with park staff to coordinate planning efforts for monitoring phase of I&M program

8) does outreach for I&M program in the form of: informal presentations to parks' staff, formal presentations at scientific and public meetings, and web page development

Currently, an Interim Network Coordinator has been hired on a temporary basis using lapse monies stemming from the backfilling of the SEKI Resource Planner position. We will recruit for the GS-11 term Network Coordinator/Data Manager when the regional I&M fund account becomes available. This position has ½ FTE dedicated to network coordination and ½ FTE dedicated to data management (see section 5 for data management details). We have also identified an essential need for network coordination support. SEKI Resource Planner, John Austin, will dedicate one-half of his time to coordinating planning efforts for the monitoring phase of the I&M program as soon as he is relieved from his Acting Natural Resources Division Chief responsibilities at SEKI. May 2001 is the earliest estimated date that he will be available for this collateral duty, and his availability date could be as late as FY 2002. We recognize the need for both a full-time Data Manager and Network Coordinator, but current funding levels are inadequate to support both as separate positions.

We anticipate that the monitoring phase of our I&M program will require additional coordination and data management responsibilities. We hope to dedicate a full-time Network Coordinator and a full-time Data Manager to the network I&M program when the monitoring phase of the program begins.

Table 6. Annual budget for network coordination and data management.

Budget Item	**2000**	**2001**	**2002**	**2003**	**2004**
• Hire and supervise Network Coordinator/Data Manager • Assist with planning for monitoring		Time of Resource Planner donated by SEKI	Time of Resource Planner donated by SEKI	Time of Resource Planner donated by SEKI	
Network Coordination		$12,500 (1/2 FTE) 5 months $5,000 (support)	$31,500 (1/2 FTE) 12 months $5,000 (support)	$31,500 (1/2 FTE) 12 months $4,000 (support)	unfunded
Data Management Coordination		$12,500 (1/2 FTE) 5 months	$31,500 (1/2 FTE) 12 months	$31,500 (1/2 FTE) 12 months	unfunded
Data Management Support	$58,000 ECOIntern salaries and support, web page development	$2,500 web page development	$20,000 GS-07 2 data specialists, 8 pay periods	$21,000 GS-07 2 data specialists, 8 pay periods	unfunded

7.3 Budget

Table 7 - Sierra Nevada Network Inventory Program Budget

Project	2000	2001	2002	2003	2004	Total
Network Coordination		**$17,500**	**$36,500**	**$35,500**		**$89,500**
Data Management	**58,000**	**15,000**	**51,500**	**52,500**		**177,000**
Vascular plant species list documentation (YOSE)		**39,000**				**39,000**
Vascular plant surveys, including non-native plants, special status plants, at DEPO	--	**25,000**				**25,000**
Special status plants in SEKI, YOSE, and DEPO	**20,000**		**25500**	**25,000**		**70,500**
Distribution and abundance of exotic plants in areas of natural disturbance (YOSE)	--	**11,000**				**11,000**
Vertebrate Survey (SEKI, YOSE, DEPO)				**95,000**		**95,000**
Caudate amphibian survey (SEKI)	**20,000**					**20,000**
Pilot Invertebrate Survey (SEKI)	**10,000**					**10,000**
Bat distribution and abundance (SEKI, DEPO)			**32,500**	**32,500**		**65,000**
Total	**$108,000**	**$107,500**	**$146,000**	**$240,500**	--	**$602,000**

7.4 Project Completion Schedule

Table 8. Project Completion Schedule

Project	2000	2001	2002	2003	2004
Data Management:					
Web Page	Web Page Development SEKI/DEPO	Web Page Development SEKI/DEPO/YOSE	Web Page Maintenance	Web Page Maintenance	Web Page Maintenance
NPSpecies	Start	Continued data gathering and input	Database maintenance	Database maintenance	Database maintenance
Dataset Catalogue/FGDC Compliant Metadata	Start at SEKI	Start at YOSE and DEPO	Continue	Finish	Data maintenance
I&M Database Template			Start	Data maintenance	Data maintenance
Develop Data Collection and Handling Standards/Protocol		Complete	Modify as Needed	Modify as Needed	Modify as Needed
Synthesis	Beta-Testing and Test Deployment	Start (SEKI,DEPO)	Modify as Needed	Update as Needed	Update as Needed
GIS Theme Manager	Beta-Testing and Test Deployment	Start	Update as Needed	Update as Needed	Update as Needed
Standardized File Structure	Develop Standards	Start	Update as Needed	Update as Needed	Update as Needed
NRBib	Updates to YOSE and SEKI Completed	Update as Needed	Update as Needed	Update as Needed	Update as Needed
Project	**2000**	**2001**	**2002**	**2003**	**2004**
Inventory Projects:					
Caudate amphibian survey (SEKI)	Field surveys	Report preparation			
Invertebrate survey (SEKI)	Field surveys	Report preparation			
Documentation of YOSE plant list		Herbarium searches and database development Report preparation			

Project	2000	2001	2002	2003	2004
Special status plants in SEKI, YOSE, and DEPO	Solicit proposals, award contract	Develop list of special status taxa Develop survey strategy Habitat-based models of high priority species	YOSE surveys	SEKI surveys	Analysis & Report preparation
Non-native plants, burned/riparian areas at YOSE, phase 1	--	Solicit proposals and award contract Develop inventory strategy under contract Prepare report			
Vascular plant surveys (non-native plants, special status plants) at DEPO		Field surveys	Report preparation		
Inventory of bat species in SEKI and DEPO				Field surveys	Field surveys Report preparation
Terrestrial vertebrate inventory			Initiate hiring Identify/map preferred habitats; design random stratified sampling strategy; test and refine field methods	Procure equipment DEPO, YOSE and SEKI surveys Data entry, analysis and report preparation	Complete report preparation

SECTION 8 - PRODUCTS AND DELIVERABLES

This section will discuss the various products and output of the biological inventory projects for the Sierra Nevada Network. Specific deliverables are listed in project descriptions in sections by that title (see Section 6). The following represent the minimum set of deliverables for the Sierra Nevada Network Biological Inventory Project:

Progress Reports

Project coordinator will oversee the timely completion and quality of all deliverables and insure that products are useful to park managers. Deliverables will include written annual reports for each year of fieldwork from each investigator. These written reports will summarize progress toward inventory objectives during the previous year, a summary of work completed, important results, and plans for the next year. In addition, researchers will complete an Investigator's Annual Report for each year of fieldwork. These reports are currently submitted using an online entry form provided by NPS and are due in January of the year following field work.

Final Reports

A draft final report will be due in January of the year following completion of field work, with the revised final report due in April of that year. At a minimum each final report will include summaries of each of the taxa, field work and inventory/metadata of materials and information submitted to the Data Set Catalog and NPSpecies. Final copies of electronic tabular data and spatial data will be due at the time of the revised final report. These will be submitted to the Network Coordinator/Data Managerwho will oversee park-level review and handle distribution to the parks, the Regional I&M Coordinator and the NPS Servicewide I&M Office. In addition, researchers will submit information on all vouchers collected (see 4.5 Voucher Policy).

ArcView GIS themes and Microsoft Access databases

These will be developed from the field data collected through the use of GPS-derived coordinates associated with each data collection site. Data for the various taxa will be entered into relational databases by project staff (field crews or otherwise). Preliminary QA/QC will be done by project staff which will then be reviewed and approved by the principal investigator (see 5.4 Data Collection and Handling). Upon approval, these data along with associated metadata, documents, maps, raw data, photographs etc. will be transferred to the Network Coordinator/Data Manager along with annual and final reports (see 5.0 Data Management).

NPS Inventory and Monitoring Databases

All databases will be developed using MS Access as the standard. All reports will be submitted in MS Word format (current NPS standard is Word 97). All new information acquired during these biological inventories will be entered into the appropriate NPS databases including NPSpecies, NRBib, Dataset Catalogue, or FGDC compliant metadata. Written language will be inserted into all contracts assuring compliance and compatibility with these standards. Oversight and enforcement will be the responsibility of the Data Manager position.

Database Updates and Maintenance. All principal investigators or survey coordinators will be required to provide digital databases that are consistent with the I&M Database structures. Updates to and maintenance of NPS databases will be the responsibility of the Network Coordinator/Data Manager.

SECTION 9 - COORDINATION AND LOGISTICAL SUPPORT

The Sierra Nevada Network Steering Committee has overall responsibility for the network inventory and monitoring program. The Network Coordinator and associated staff work to implement the program as directed by the steering committee. Periodic meetings between the steering committee and program staff ensure that key decisions and program needs are addressed in a timely manner. Regular communication between the Network Coordinator/Data Manager and steering committee ensures a smoothly functioning program.

Network parks and I&M project staff will assist with on-site supervision and logistical support needed to complete field inventories and data management tasks. Specific levels of support available within each park are described in the paragraphs below.

Yosemite National Park

Housing. Limited short-term housing will be made available to support NPS field staff associated with vertebrate surveys (Project 6.5) and vascular plant surveys (Projects 6.1, 6.3, 6.6). Contractors will be required to arrange for their own lodging in surrounding communities (El Portal, Mariposa, and Lee Vining). Camping facilities can be arranged with several months notice at sites throughout the park.

Office space and computer support. Shared office space with phone and computer access will be made available for NPS inventory staff in El Portal. Limited access to phone and computer resources will be provided to contractors on a short-term basis as needed.

Vehicles. Project coordinators will be responsible for acquiring vehicles for NPS field staff through either GSA or private contract, depending on availability. Contractors will be required to provide their own transportation while conducting work within the park.

Packstock support. Although limited NPS packstock support may be available for transporting supplies into remote field sites, commercial packers will be relied upon as necessary in most cases.

Sequoia and Kings Canyon National Parks

Housing. Limited short-term housing will be made available to support NPS field staff associated with vertebrate surveys (Project 6.5) and vascular plant surveys (Projects 6.1, 6.3, 6.6) through a competitive bid process. If adequate housing is not available through the bid process, employees will be required to arrange for lodging in the surrounding community (Three Rivers). In some cases a long-term field camp may be established to support field personnel. Contractors will be required to arrange for their own lodging in the surrounding community. A limited number of dormitory facilities are available for short-term use by contract researchers at the Southern Sierra Research Center; the USGS Field Station located at park headquarters administers these. Short-term camping facilities are available at sites throughout the two parks on a limited basis.

Office space and computer support. Shared office space with phone and computer access will be made available for NPS inventory staff at park headquarters. Limited access to phone and computer resources will be provided to contractors on a short-term basis as needed.

Vehicles. Project coordinators will be responsible for acquiring vehicles for NPS field staff through either GSA or private contract, depending on availability. Contractors will be required to provide their own transportation while conducting work within the park.

Packstock support. Although limited NPS packstock support may be available for transporting supplies into remote field sites, commercial packers will be relied upon as necessary in most cases.

Helicopter support. Where funding allows, access to the park contract helicopter for transporting supplies into remote field sites will be made available. Helicopter use will be subject to established guidelines and flight availability.

Devils Postpile National Monument

Housing. Limited short-term rustic housing may be available to support NPS field staff associated with vertebrate surveys (Project 6.5) and vascular plant surveys (Projects 6.1, 6.3, 6.6). Contractors will be required to arrange for their own lodging in surrounding community (Mammoth Lake).

Office space and computer support. Limited access to phone and computer resources will be provided to NPS field staff and contractors on a short-term basis as needed. NPS field staff will be provided with a dedicated laptop computer while stationed at the monument.

Vehicles. Project coordinators will be responsible for acquiring vehicles for NPS field staff through either GSA or private contract, depending on availability. Contractors will be required to provide their own transportation while conducting work within the monument.

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